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CONCERNING A FILING UNDER 35 U.S.C. 371

147-199P PCT

U.S. APPLICATION NO. (If known, see 37 CFR 1.5)

09/532465 NEW

PRIORITY DATE CLAIMED

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	
PCT/EP98/07313	November 16, 1998	November 17, 1997

## TITLE OF INVENTION

A NOVEL METHOD OF IDENTIFYING BINDING SITE DOMAINS THAT RETAIN THE CAPACITY OF BINDING TO AN EPITOPE

## APPLICANT(S) FOR DO/EO/US

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Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

- This is a FIRST submission of items concerning a filing under 35 U.S.C. 371.
- This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371.
- This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39 (1).
- A proper Demand for International Preliminary Examination was made by the 19<sup>th</sup> month from the earliest claimed priority date
- A copy of the International Application as filed (35 U.S.C. 371(c)(2))
  - a.  is transmitted herewith (required only if not transmitted by the International Bureau).
  - b.  has been transmitted by the International Bureau.
  - c.  is not required, as the application was filed in the United States Receiving Office (RO/US).
- A translation of the International Application into English (35 U.S.C. 371(c)(3)).
- Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(2)).
  - a.  are transmitted herewith (required only if not transmitted by the International Bureau).
  - b.  have been transmitted by the International Bureau.
  - c.  have not been made; however, the time limit for making such amendments has NOT expired.
  - d.  have not been made and will not be made.
- A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
- An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
- A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

## Items 11. to 16. below concern document(s) or information included:

11.  An Information Disclosure Statement under 37 CFR 1.97 and 1.98.-1449 and International Search Report (PCT/ISA/210)
12.  An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13.  A FIRST preliminary amendment.  
 A SECOND or SUBSEQUENT preliminary amendment.
14.  A substitute specification.
15.  A change of power of attorney and/or address letter.
16.  Other items or information:
  - 1.) International Preliminary Examination Report (PCT/IPEA/409)
  - 2.) PCT Demand (PCT/IPEA/401)
  - 3.) PCT Request (PCT/RO/101)
  - 4.) Sequence Listing (48 pages)
  - 5.) Forty (40) sheets of Formal Drawings



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INTERNATIONAL APPLICATION NO

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17.  The following fees are submitted:

**BASIC NATIONAL FEE (37 CFR 1.492(a)(1)-(5):**

Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO. .... \$970.00

International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO ..... \$840.00

International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO. .... \$690.00

International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) ..... \$670.00

International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4). .... \$96.00

**ENTER APPROPRIATE BASIC FEE AMOUNT =**

Surcharge of \$130.00 for furnishing the oath or declaration later than  20  30 months from the earliest claimed priority date (37 CFR 1.492(e)).

**CALCULATIONS PTO USE ONLY**

/cqc May 12, 2000

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526 Rec'd PCT/PTO 12 MAY 2000

PATENT  
147-199P

IN THE U.S. PATENT AND TRADEMARK OFFICE

Applicant: KUFER, Peter et al.

Int'l. Appl. No.: PCT/EP98/07313

Appl. No.: New Group:

Filed: May 12, 2000 Examiner:

For: A NOVEL METHOD OF IDENTIFYING  
BINDING SITE DOMAINS THAT RETAIN  
THE CAPACITY OF BINDING TO AN  
EPITOPE

PRELIMINARY AMENDMENT

**BOX PATENT APPLICATION**

Assistant Commissioner for Patents  
Washington, DC 20231

May 12, 2000

Sir:

The following Preliminary Amendments and Remarks are respectfully submitted in connection with the above-identified application.

AMENDMENTS

**IN THE SPECIFICATION:**

Please amend the specification as follows:

Before line 1, insert --This application is the national phase under 35 U.S.C. § 371 of PCT International Application No. PCT/EP98/07313 which has an International filing date of November 16, 1998, which designated the United States of America.--

**IN THE CLAIMS:**

Please amend the claims as follows:

**Claim 4:** Line 1, change "any one of claims 1 to 3" to  
--claim 1--

**Claim 6:** Line 1, change "any one of claims 1 to 5" to  
--claim 1--

**Claim 8:** Line 1, change "any one of claims 1 to 7" to  
--claim 1--

**Claim 10:** Line 1, change "any one of claims 1 to 9" to  
--claim 1--

**Claim 11:** Line 1, change "any one of claims 1 to 8" to  
--claim 1--

**Claim 19:** Line 1, change "any one of claims 3 to 18" to  
--claim 3--

**Claim 20:** Line 1, change "any one of claims 1 to 19" to  
--claim 1--

**Claim 22:** Line 1, change "any one of claims 1 to 20" to  
--claim 1--

**REMARKS**

The specification has been amended to provide a cross-reference to the previously filed International Application. The claims have also been amended to delete the improper multiple dependencies and to place the application into better

Docket No. 147-199P

examination. Entry of the present amendment and favorable action on the above-identified application are respectfully requested.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies, to charge payment or credit any overpayment to Deposit Account No. 02-2448 for any additional fees required under 37 C.F.R. § 1.16 or under 37 C.F.R. § 1.17; particularly, extension of time fees.

Respectfully submitted,

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LRS/cqc  
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PCT/EP98/07315

WO 99/25818  
opt

METHOD OF IDENTIFYING BINDING SITE DOMAINS THAT RETAIN THE CAPACITY OF BINDING TO AN EPITOPE

The present invention relates to a method of identifying domains having binding affinity for a preselected epitope. The domains comprise preferably immunoglobulin V<sub>H</sub> and V<sub>L</sub> domains that retain the capacity of binding to an epitope when positioned C-terminal of at least one further domain in a recombinant bi- or multivalent polypeptide. The present invention further relates to a kit comprising components such as panels of recombinant vectors or bacterial libraries transfected with a panel of recombinant vectors which is useful in carrying out the method of the invention. Furthermore, the present invention relates to polypeptides obtainable by the afore-described method and their use in pharmaceutical and diagnostic compositions.

Multivalent receptors such as recombinant bifunctional antibody constructs play an increasingly important therapeutic and scientific role in particular in the medical field, for example, in the development of new treatment approaches for cancer and autoimmune diseases or as interesting tools for the analysis and modulation of cellular signal transduction pathways, pioneer work has been done using such receptors.

Thus, by cross-linking of the CD3-activation antigen on T cells with a tumor associated antigen on tumor cells, bispecific single-chain antibodies can bring both cells together so that the tumor cell is efficiently lysed during the cell-cell contact (Mack, Proc. Natl. Acad. Sci. U.S.A. 92 (1995) 7021-7025). Comparable approaches have been or are being developed for other target cells (e.g. virus-infected cells) and for the recruitment of other effector cell populations (e.g. NK-cells and mononuclear phagocytes). Using bifunctional fusion proteins that carry an antibody fragment as targeting mechanism, a large number of different receptors and ligands can be

specifically bound to defined surface molecules on selected cell populations. It is particularly interesting that surface molecules on the same cell can be cross-linked by bi-specific antibodies in order to modulate cellular function or the state of activation or differentiation of such cells. A possible application of this type of approach may be the induction of anergy in auto-aggressive B- or T-lymphocytes that play a pathogenetic role in many autoimmune diseases. Regarding the broad scientific and therapeutic relevance, efficient and reproducible methods for producing recombinant polypeptides comprising functional antigen binding sites are of particular importance; such methods yield, for example, functionally active bispecific antibody constructs by expression in bacteria and in mammalian cells. Said recombinant bifunctional single-chain proteins usually are built up by different scFv-antibody fragments, each of which consists of one immunoglobulin variable heavy ( $V_H$ ) and one variable light ( $V_L$ )-antigen binding domain. Alternatively, they may comprise such an antibody fragment and one non-immunoglobulin part. All functional domains are located on a single polypeptide chain and joined together by flexible Glycin-Serin- or other appropriate peptide linkers. The bifunctional polypeptide chain can be produced as functional protein by transfecting mammalian or less preferentially other host cells with the corresponding DNA-sequence, that additionally may encode an optional protein-tag, preferentially a poly-histidine-tag, enabling easy purification of the recombinant protein for example by using a nickel-chelate-column. The production of multivalent and preferably bifunctional constructs according to this single-chain approach has important advantages compared to conventional methods using in vitro- or in vivo-heterodi- or multimerization of independently expressed functional domains, a procedure that can be very laborious and frequently associated with low yields. The appearance of contaminating homodimers is excluded by the single-chain approach, thus resulting in protein preparations of high purity and yield since all the recombinant protein produced consists to 100% of the desired bifunctional construct. As has been demonstrated by way of example with a bispecific single-chain antibody functionally expressed in CHO-cells, scFv-antibody fragments can in principle bind to their antigen either as the N-terminal or the C-terminal part of a bifunctional single-chain construct, (Mack, Proc. Natl. Acad. Sci. U.S.A. 92(1995) 7021-7025).

However, many functional domains of multivalent polypeptides such as antibody fragments lose their binding activity when located C-terminal of a further three-dimensional proteinaceous structure within a fusion protein. For example, scFv-fragments derived from randomly selected antibodies produced by hybridoma cell lines or selected in vitro from combinatorial antibody libraries frequently lose their antigen binding activity when located at the C-terminal position within recombinant bifunctional single-chain proteins, although the same  $V_H/V_L$ -pairs bind to the antigen when located at the N-terminus or as whole antibodies or free monovalent scFv-fragments (Figure 10). This phenomenon was, by way of reference Examples, extensively characterized with recombinant bifunctional single-chain molecules consisting at the N-terminus of the extra-cellular part of human CD80 (B7-1) followed at the C-terminus by different scFv-fragments derived from antibodies that specifically bind to the 17-1A-antigen (Figure 1.1). Of four different 17-1A-specific antibodies, three of which were produced by murine hybridoma cell lines and one selected in vitro from a human combinatorial antibody library using the phage display method, none gave rise to a scFv-fragment that retains its antigen binding activity when fused with its N-terminus to the C-terminus of the human CD80-fragment and expressed as bifunctional single-chain molecule in CHO-cells (Examples 1-4). It is noteworthy that two of the murine antibody fragments (M79 and M74) bind to the 17-1A-antigen as N-terminal part of bi-specific single-chain antibodies (Mack, Proc. Natl. Acad. Sci. U.S.A. (1995) 7021-7025) as well as in the form of free monovalent scFv-fragments, the latter of which was also shown for the human 17-1A-specific antibody VD4.5VK8 (Example 3) derived in vitro from a phage library. All four specificities bind to the 17-1A-antigen in the form of whole antibody molecules. Accordingly, the technical problem underlying the present invention was to provide means and methods to identify bi- or multivalent polypeptides that comprise antibody binding sites capable of efficiently binding to the corresponding antigen. The solution to said technical problem is achieved by providing the embodiments characterized in the claims.

Thus, the present invention relates to a method of identifying a binding site domain having the capacity of binding to a predetermined epitope when positioned C-terminal of at least one further domain in a recombinant bi- or multivalent polypeptide comprising the steps of

- (a) testing a panel of binding site domains displayed on the surface of a biological display system as part of a fusion protein for binding to a predetermined epitope, wherein said fusion protein comprises an additional domain positioned N-terminal of said binding site domain and an amino acid sequence that mediates anchoring of the fusion protein to the surface of said display system; and
- (b) identifying a binding site domain that binds to said predetermined epitope.

Preferably, the binding site domain capable of binding to a preselected antigenic determinant comprises an amino acid sequence homologous with the sequence of a variable region of an immunoglobulin molecule capable of binding said preselected epitope.

The term "binding site domain" as used in accordance with the present invention denotes a domain comprising a three-dimensional structure capable of binding to an epitope.

The term "bi- or multivalent polypeptide" as used herein denotes a polypeptide comprising at least two amino acid sequences derived from different origins wherein one of said origins specifies the binding site domain.

In accordance with the present invention, the term "capacity of binding to an epitope" denotes the capacity of said binding site domain to enter and bind a corresponding epitope, like native antibodies or free scFv fragments.

The term "panel" as used in accordance with the present invention relates to two or more pairs of the recited domains. Preferably, said panel is derived from a library such as a cDNA library, or, more preferably, a combinatorial library of, e.g., V<sub>H</sub>/V<sub>L</sub> chains.

The fusion protein is capable of binding to a preselected epitope and preferably, has a specificity at least substantially identical to the binding specificity of the, e.g., immunoglobulin molecule where it is derived from. Such binding site domains can have a binding affinity of at least  $10^6 M^{-1}$ , preferably  $10^8 M^{-1}$  and advantageously up to  $10^{10} M^{-1}$  or higher.

The additional domain present in the fusion protein may be linked by a polypeptide linker to the binding site domain. Furthermore, said additional domain may be of a predefined specificity or function. For example, the literature contains a host of references to the concept of targeting bioactive substances such as drugs, toxins, and enzymes to specific points in the body to destroy or locate malignant cells or to induce a localized drug or enzymatic effect. It has been proposed to achieve this effect by conjugating the bioactive substance to monoclonal antibodies (see, e.g., N.Y. Oxford University Press; and Ghose, (1978) J. Natl. Cancer Inst. 61:657-676). However, constructing corresponding targeted multifunctional proteins is hampered by the fact that the chimeric proteins loose their binding affinity and/or specificity due to the presence of extra sequences and guess work turned out to be insufficient to remedy this obstacle.

The method of the present invention can solve this problem and thus can be used to prepare and identify such multi-functional proteins which substantially retain both, the binding affinity and the function of the additional domain(s).

In a preferred embodiment of the method of the invention the binding site domain and said additional domain are linked by a polypeptide linker disposed between said binding site and said additional domain, wherein said polypeptide linker comprises plural, hydrophilic, peptide-bonded amino acids and connects the N-terminal end of said binding site and the C-terminal end of said additional domain.

As well known, Fv, the minimum antibody fragment which contains a complete antigen recognition and binding site, consists of a dimer of one heavy and one light chain variable domain ( $V_H$  and  $V_L$ ) in noncovalent association. It is in this configuration that the three complementarity determining regions (CDRs) of each variable domain interact to define an antigen binding site on the surface of the  $V_H$ - $V_L$  dimer. Collectively, the six CDRs confer antigen binding specificity to the antibody. Frameworks (FRs) flanking the CDRs have a tertiary structure which is essentially

conserved in native immunoglobulins of species as diverse as human and mouse. These FRs serve to hold the CDRs in their appropriate orientation. The constant domains are not required for binding function, but may aid in stabilizing  $V_H$ - $V_L$  interaction. Even a single variable domain (or half of an Fv comprising only three CDRs specific for an antigen) has the ability to recognize and bind antigen, although at a lower affinity than an entire binding site (Painter (1972) Biochem. 11:1327-1337).

Hence, in a particularly preferred embodiment of the method of the invention, said binding site domain is a pair of  $V_H$ - $V_L$ ,  $V_H$ - $V_H$  or  $V_L$ - $V_L$  domains either of the same or of different immunoglobulins.

The order of  $V_H$  and  $V_L$  domains within the polypeptide chain is not decisive for the present invention, the order of domains given herein above may be reversed without any loss of function. It is important, however, that the  $V_H$  and  $V_L$  domains are arranged so that the antigen binding site can properly fold.

In accordance with the present invention, the term "identify" relates, in its broadest sense, to the identification of a clone that comprises the properly binding site domain, preferably said clone can be purified and the sequence of the binding site domain, e.g.,  $V_H$  and  $V_L$  domains may be determined.

Naturally, the method of the invention is not only applicable to the identification of a single pair of  $V_H$  and  $V_L$  domains, but may also be applied to the identification and isolation of a variety of such pairs.

Prior to establishing the method of the invention, a variety of parameters were considered that were expected to possibly influence the binding activity of scFv-antibody fragments located at the C-terminus of multivalent polypeptides, in particular of bifunctional single-chain molecules. Thus, constructs with 5- and 15-amino acid glycine-serin-linkers between the CD80- and the scFv-fragment as well as alternative domain arrangements, namely  $V_L$ - $V_H$  and  $V_H$ - $V_L$  within the C-terminal scFv-fragment were produced and analysed for antigen binding (Examples 1 and 2).

However, antigen binding of scFv-fragments that lost their binding activity due to their position at the C-terminus of bifunctional single-chain molecules could not be reconstituted by using different linker lengths and/or by changing the arrangement of the V<sub>L</sub>- and the V<sub>H</sub>-domains in any Example tested.

Surprisingly, it was now found in accordance with the present invention that by using a novel in vitro selection method based on the phage display technology (Figure 11), scFv-antibody fragments that bind independently of their position within bifunctional single-chain fusion proteins could be isolated from, by way of Example, combinatorial antibody libraries, (Examples 5 and 6).

The present invention thus significantly extends the applicability of multivalent polypeptides such as bifunctional single-chain molecules.

To functionally simulate the C-terminal context in multivalent polypeptides exemplified by bifunctional single-chain constructs, the N-terminus of V<sub>H</sub>-V<sub>L</sub>-scFv-antibody fragments, respectively that of the V<sub>H</sub>-domain, was fused to the C-terminus of a stretch of amino acids folding into a three-dimensional structure. Experimentally, this was achieved by employing the N2-domain of the gene III-product of filamentous phage (Krebber, FEBS Letters 377 (1995) 227-231). Accordingly, the N2-domain plays the role of a surrogate for any preferably functional domain located at the N-terminus of a pair of V<sub>H</sub> and V<sub>L</sub> domains within a bi- or multivalent single-chain protein. The "N-terminally blocked" scFv-fragment N2-V<sub>H</sub>-V<sub>L</sub>, respectively the C-terminus of V<sub>L</sub>, was fused to an amino acid sequence that mediates anchoring of the fusion protein to the surface of a phage. Experimentally, this was effected by employing the N-terminus of the C-terminal CT-domain of the gene III-filamentous phage product (Barbas, Proc. Natl. Acad. Sci. U.S.A. 88 (1991) 7978-7982). In the following, the invention will be explained in more detail on the basis of the experiments that were actually carried out: The DNA encoding the fusion protein N2-V<sub>H</sub>-V<sub>L</sub>-CT can be cloned into a phagemid vector (e.g. pComb3H) and transformed into a male E.coli-strain (e.g. XL1-blue) that will, after infection with a filamentous helper phage, produce phage particles carrying the N2-V<sub>H</sub>-V<sub>L</sub>-CT-fusion protein on their surface and containing a single-stranded copy of the corresponding DNA. This

coupling of phenotype and genotype enables to select and enrich - by several rounds of panning on the antigen - from large repertoires of  $V_H/V_L$ -combinations those "N-terminally blocked" scFv-antibody fragments that nevertheless retain their antigen binding activity. To test the method of the invention, mice were immunized with recombinant soluble 17-1A-antigen; animals with detectable anti-17-1A serum antibody titer were sacrificed, total RNA was prepared from the murine spleen cells and reverse-transcribed into cDNA using random hexamer priming. The  $V_L$ - and  $V_H$ -repertoire of the current antibody response was amplified by PCR using  $V_L$ - and  $V_H$ -subfamily specific oligonucleotide primers and cloned into the phagemid vector pComb3H already containing the DNA-sequences encoding the N2- and the CT-domain of the gene III-product of filamentous phage. This combinatorial antibody library was transformed into the E.coli-strain XL1-blue to subsequently proceed with the in vitro-selection by panning on immobilized 17-1A-antigen according to the phage display method (Winter, Annu. Rev. Immunol. 12 (1994) 433-455; Barbas, METHODS, A companion to Methods in Enzymology 2 (1991) 119-124). After the third, fourth and fifth round of panning, soluble N2- $V_H$ - $V_L$ -single chain fragments of individual clones were generated by the excision of the gene III-CT-sequence prior to the periplasmatic expression in E.coli and tested by ELISA for binding to immobilized 17-1A-antigen. The  $V_L$ - and  $V_H$ -regions of "N2-blocked" scFv-fragments that bound to the 17-1A-antigen were sequenced and subcloned into the mammalian expression vector pEF-DHFR already containing the coding sequence of the extra-cellular CD80-fragment thus resulting in a final construct that encodes a bifunctional single-chain protein with the CD80-fragment located at the N-terminal position (Example 7). In addition, one  $V_H$ - $V_L$ -pair derived from a 17-1A-specific murine hybridoma cell line (Example 4) and another 17-1A-specific  $V_H$ - $V_L$ -pair selected from a human combinatorial antibody library by the conventional phage display method (Example 3) were also cloned into this bifunctional context. The bifunctional single-chain constructs were transfected into DHFR-deficient CHO-cells using nucleoside-free culture medium for the primary selection and the protein expression was subsequently increased by gene amplification using the DHFR-inhibitor methotrexat at a final concentration of 20nM. The recombinant bifunctional proteins were secreted into the culture supernatant; the culture supernatants from

the different clones were analysed for antigen binding by ELISA on immobilized recombinant 17-1A-antigen (Example 8) and by flow cytometry on CHO-cells transfected with the transmembrane form of the 17-1A-antigen (Example 9). All of the nine different bifunctional single-chain constructs derived from the method of the invention proved to bind to the 17-1A-antigen as demonstrated in both binding assays (ELISA and FACS) (Figures 8.1, 8.2 and 9.1); both conventionally derived bifunctional single-chain constructs, however, failed to bind to the 17-1A-antigen (Figures 8.3, 8.4 and 9.1). As shown in Example 10 it could be further confirmed that specific antigen binding of scFv-antibody fragments obtained by the method of the invention does not depend on a particular further N-terminal domain (like the extracellular part of CD80) within a bifunctional single chain protein. Taken together, these data demonstrate that scFv-antibody fragments that retain their antigen binding activity at the C-terminal position of bifunctional single-chain proteins can be selectively obtained by the method of the invention involving an N-terminal surrogate domain simulating the effect of other functional domains fused to the N-terminus of scFv-antibody fragments. This exemplary approach can, by the person skilled in the art, be transferred to any other pair of  $V_H$  and  $V_L$  domains comprised in a multivalent polypeptide in the above indicated position(s).

In a preferred embodiment of the present invention, said biological display system is filamentous phage produced by bacteria transfected therewith, a baculovirus expression system, a ribosome based display system, a bacteriophage lambda display system or a bacterial surface expression system based, for example, on the *ompA* protein.

An Example of a ribosome display system has been described, for example, by Hanes, Proc. Natl. Acad. Sci. U.S.A. 94 (1997) 4937-4942. Examples of the other systems referred to above are well established in the art (Mottershead, Biochem. Biophys. Res. Commun. 238 (1997) 717-722; Sternberg, Proc. Natl. Acad. Sci. U.S.A. 92 (1995) 1609-1613; Stahl, Trends Biotechnol, 15 (1997) 185-192).

As regards the bacteria transfected with the phage, it is preferred that the bacteria are E.coli.

Referring now to the experimental procedure used to explain the invention and described herein above, in a further preferred embodiment of the invention, said method comprises prior to step (a), the further step of (a'') transfecting bacteria with recombinant vectors encoding said fusion proteins. Preferably, said vectors are phagemid vectors.

In a further preferred embodiment of the invention, said method comprises prior to step (a''), the further step of (a') cloning a panel of nucleic acid molecules encoding the binding site domain, e.g., pairs of V<sub>H</sub> and V<sub>L</sub> domains into a vector.

In a most preferred embodiment of the invention, said panel of nucleic acid molecules is derived from immune competent cells of a mammal, fish or bird. This embodiment is particularly preferred insofar as it reflects the immune repertoire of the B-cell compartment of the mammal which may be amplified and cloned by RT-PCR using V<sub>L</sub>- and V<sub>H</sub>-specific oligonucleotide primers or primer sets.

In an additional preferred embodiment of the invention, said additional domain comprises at least 9 amino acids.

Preferably, said additional domain is not sufficient to mediate phage infectivity when displayed on the surface of phage particles.

In a most preferred embodiment of the invention, said additional domain is or is derived from the N2-domain of the gene III product of filamentous phage. Preferably, N2 is not capable of mediating infectivity of the phage.

In a preferred embodiment of the invention, said sequence mediating said anchoring is or is derived from the C-terminal CT-domain of the gene III product of filamentous phage. However, other suitable domains known to be capable of mediating anchoring to surfaces of, e.g., phage displays may be used as well.

In a further preferred embodiment of the invention, said bi- or multivalent polypeptide is a bi- or multifunctional polypeptide.

In a most preferred embodiment of the invention, said at least one further domain comprises a polypeptide selected from the group consisting of effector proteins having a conformation suitable for biological activity, amino acid sequences capable of sequestering an ion, and amino acid sequences capable of selective binding to a solid support.

Preferably, said effector protein is an enzyme, toxin, receptor, binding site, biosynthetic antibody binding site, growth factor, cell-differentiation factor, lymphokine, cytokine, hormone, a remotely detectable moiety, or anti-metabolite.

Furthermore, said sequence capable of sequestering an ion is preferably selected from calmodulin, methallothionein, a fragment thereof, or an amino acid sequence rich in at least one of glutamic acid, aspartic acid, lysine, and arginine.

In addition, said polypeptide sequence capable of selective binding to a solid support can be a positively or negatively charged amino acid sequence, a cysteine-containing amino acid sequence, avidin, streptavidin, or a fragment of Staphylococcus protein A.

The effector proteins and amino acid sequences described above may be present in a proform which itself is either active or not and which may be removed, when, e.g., entering a certain cellular environment.

In a most preferred embodiment of the invention, said receptor is a costimulatory surface molecule important for T-cell activation or comprises an epitope binding site or a hormone binding site.

In a further most preferred embodiment of the invention, said costimulatory surface molecule is CD80 (B7-1), CD86 (B7-2), CD58 (LFA-3) or CD54 (ICAM-1).

In a further most preferred embodiment of the invention, said epitope binding site is embedded in a pair of  $V_H$ - $V_L$ ,  $V_H$ - $V_H$  and  $V_L$ - $V_L$  domains.

In a preferred embodiment of the invention, said  $V_H$  and/or  $V_L$  domains are connected by a flexible linker, preferably by a polypeptide linker disposed between said domains, wherein said polypeptide linker comprises plural, hydrophilic, peptide-bonded amino acids of a length sufficient to span the distance between the C-terminal end of one of said domains and the N-terminal end of the other of said domains when said fusion protein assumes a conformation suitable for binding when disposed in aqueous solution.

In a further preferred embodiment of the invention, the identification of said binding site domain comprises the steps of

- (a) removing said amino acid sequence that mediates anchoring of the fusion protein to the surface of a phage from said fusion protein;
- (b) periplasmatically expressing the nucleic acid molecules encoding the remainder of said fusion protein in bacteria; and
- (c) verifying whether said binding site domain binds to said predetermined epitope.

In another embodiment the present invention relates to a recombinant vector as defined in the above-described embodiments and to a host cell harboring and capable of expressing such a recombinant vector.

In a further preferred embodiment of the invention, the kit comprises

- (a) the described recombinant vector or a panel of recombinant vectors encoding a panel of fusion proteins as defined in the embodiments described above; and/or
- (b) the described host cell or a bacterial library transfected with a panel of vectors as defined in (a).

Furthermore, the present invention relates to a binding site domain or fusion protein obtainable by the method of the invention as characterized in the embodiments above. Advantageously, the amino acid sequence that mediates anchoring of the fusion protein to the surface of a phage of said fusion protein is removed from the fusion protein. Thus, the resultant fusion protein may only comprise the binding site domain and an additional domain, preferably an effector protein as described above.

In a preferred embodiment of the present invention, the binding site domain, for example contained in a fusion protein comprises at least one complementarity determined region (CDR) of the scFv fragment shown in any one of Figures 6.3 to 6.10 and 7. The person skilled in the art knew that each variable domain comprises three hypervariable regions, sometimes called complementarity determining regions or "CDRs" flanked by four relatively conserved framework regions or "FRs". The CDRs contained in the variable regions shown in Figures 6.3 to 6.10 and 7 can be determined according to Kabat, Sequences of Proteins of Immunological Interest (U.S. Department of Health and Human Services, third edition, 1983, fourth edition, 1987, fifth edition 1990).

The person skilled in the art will readily appreciate that the binding site domain or fusion protein identified according to the method of the invention or at least one CDR derived therefrom can be used for the construction of other polypeptides or antibodies of desired specificity and biological function. Thus, the present invention also relates to polypeptides and antibodies comprising a binding site domain or fusion protein of the invention. Preferably, said polypeptide or antibody comprises the amino acid sequence as depicted in any one of Figures 6.3 to 6.10 and 7. The person skilled in the art will readily appreciate that using the binding sites or CDRs described above antibodies can be constructed according to methods known in the art, e.g., as described in EP-A1 0 451 216 and EP-A1 0 549 581.

Yet in a further embodiment, the present invention relates to polynucleotides which upon expression encode the above-described polypeptides and antibodies. Said polynucleotides may be fused to suitable expression control sequences known in the art to ensure proper transcription and translation of the polypeptide.

Furthermore, the polynucleotides may be comprised in a vector which further comprises a selectable marker.

In a still further embodiment, the present invention relates to a cell containing the polynucleotide described above. Preferably, said cell is a mammalian cell if therapeutic uses of the polypeptide are envisaged. Of course, yeast and bacterial cells may serve as well, in particular if the produced polypeptide is used as a diagnostic means.

In a further embodiment, the present invention thus relates to a process for the preparation of a fusion protein obtainable by the method according to the invention, a polypeptide or antibody as described above comprising cultivating a cell of the invention under conditions suitable for the expression of the fusion protein or polypeptide and isolating the fusion protein, polypeptide or antibody from the cell culture medium.

Moreover, the present invention relates to a pharmaceutical composition containing a fusion protein, polypeptide or antibody of the invention and optionally a pharmaceutically acceptable carrier.

As to a further embodiment, the present invention relates to a diagnostic composition comprising a fusion protein, polypeptide or antibody as described above and optionally suitable means for detection.

The present invention allows recombinant production of single chain binding sites having affinity and specificity for a predetermined epitope. This technology has been developed and is disclosed herein. In view of this disclosure, persons skilled in recombinant DNA technology, protein design, and protein chemistry can produce such sites which, when disposed in solution, have high binding constants (usually at least  $10^6$ , preferably  $10^8 M^{-1}$ ) and excellent specificity. As is evident from the foregoing, the invention provides a large family of binding site domains and fusion proteins as well as polypeptides comprising such binding site domains and fusion

proteins for any use in therapeutic and diagnostic approaches. It will be apparent to those skilled in the art that the binding site domains and fusion proteins can be further coupled to other moieties for, e.g., drug targeting and imaging applications. Such coupling may be conducted chemically after expression of the fusion proteins or polypeptides to site of attachment or the coupling product may be engineered into the polypeptide of the invention at the DNA level. The DNAs are then expressed in a suitable host system, and the expressed proteins are collected and renatured, if necessary. As described above, the binding site domain is preferably derived from the variable region of antibodies, preferably monoclonal antibodies. In this respect, hybridoma technology enables production of cell lines secreting antibody to essentially any desired substance that produces an immune response. RNA encoding the light and heavy chains of the immunoglobulin can then be obtained from the cytoplasm of the hybridoma. The 5' end portion of the mRNA can be used to prepare cDNA to be used in the method of the present invention.

The DNA encoding the fusion proteins obtained according to the method of the invention can then be expressed in cells, preferably mammalian cells.

Depending on the host cell, renaturation techniques may be required to attain proper conformation. The various proteins can then be further tested for binding ability, and one having appropriate affinity can be selected for incorporation into a polypeptide of the type described above. If necessary, point substitutions seeking to optimize binding may be made in the DNA using conventional cassette mutagenesis or other protein engineering methodology such as is disclosed below.

Preparation of the polypeptides of the invention also is dependent on knowledge of the amino acid sequence (or corresponding DNA or RNA sequence) of bioactive proteins such as enzymes, toxins, growth factors, cell differentiation factors, receptors, anti-metabolites, hormones or various cytokines or lymphokines. Such sequences are reported in the literature and available through computerized data banks.

The DNA sequences of the binding site and the second protein domain are fused using conventional techniques, or assembled from synthesized oligonucleotides, and then expressed using equally conventional techniques.

The processes for manipulating, amplifying, and recombining DNA which encode amino acid sequences of interest are generally well known in the art, and therefore, not described in detail herein. Methods of identifying and isolating genes encoding antibodies of interest are well understood, and described in the application and other literature. In general, the methods involve selecting genetic material coding for amino acids which define the proteins of interest, including the CDRs and FRs of interest, according to the genetic code.

Accordingly, the construction of DNAs encoding proteins as disclosed herein can be done using known techniques involving the use of various restriction enzymes which make sequence specific cuts in DNA to produce blunt ends or cohesive ends, DNA ligases, techniques enabling enzymatic addition of sticky ends to blunt-ended DNA, construction of synthetic DNAs by assembly of short or medium length oligonucleotides, cDNA synthesis techniques, and synthetic probes for isolating immunoglobulin or other bioactive protein genes. Various promoter sequences and other regulatory DNA sequences used in achieving expression, and various types of host cells are also known and available. Conventional transfection techniques, and equally conventional techniques for cloning and subcloning DNA are useful in the practice of this invention and known to those skilled in the art. Various types of vectors may be used such as plasmids and viruses including animal viruses and bacteriophages. The vectors may exploit various marker genes which impart to a successfully transfected cell a detectable phenotypic property that can be used to identify which of a family of clones has successfully incorporated the recombinant DNA of the vector.

These and other embodiments are disclosed and encompassed by the description and Examples of the present invention. For example, further literature concerning any one of the methods, uses and compounds to be employed in accordance with

the present invention may be retrieved from public libraries, using for example electronic devices. For example the public database "Medline" may be utilized which is available on the Internet, for example under <http://www.ncbi.nlm.nih.gov/PubMed/medline.html>. Further databases and addresses, such as <http://www.ncbi.nlm.nih.gov/>, <http://www.infobiogen.fr/>, [http://www.fmi.ch/biology/research\\_tools.html](http://www.fmi.ch/biology/research_tools.html), <http://www.tigr.org/>, are known to the person skilled in the art and can also be obtained using, e.g., <http://www.lycos.com>. An overview of patent information in biotechnology and a survey of relevant sources of patent information useful for retrospective searching and for current awareness is given in Berks, TIBTECH 12 (1994), 352-364.

The figures show:

Figure 1.1: Design of various bifunctional CD80-scFv-constructs showing the construction elements on the protein-level.  $V_H$  indicates the variable region of the Ig-heavy chain,  $V_L$  that of the Ig-light chain. The single-chain-Fv-fragments used in the present invention are given in the Examples 1, 2, 3, 4 and 9.

Figure 1.2: DNA sequence designated CTI that was cloned into the multiple cloning site of the Bluescript KS vector (GenBank® accession number X52327) by using the restriction sites XbaI and SalI in order to increase the number of possible cloning sites. CTI-derived restriction enzyme cleavage sites are shown.

Figure 1.3: Design of various bifunctional CD80-scFv-constructs showing the construction elements on the DNA-level as well as the restriction enzyme cleavage sites used.

Figure 1.4: ELISA-analysis of the cell-culture supernatant obtained from CHO cells transfected with the expression plasmid pEF-DHFR+CTI+CD80-M79scFv( $V_L/V_H$ ) including the coding sequence of the short ( $Gly_4Ser_1$ )<sub>1</sub> linker. 96 well ELISA plates were incubated with 50µl of soluble 17-1A antigen (50µg/ml) per well. Subsequently pure cell-culture supernatant dilutions thereof were added as indicated. Detection

was performed by a murine IgG1 anti His-tag antibody (dianova, Hamburg) diluted 1:200 and a peroxidase conjugated polyclonal goat anti mouse IgG (Fc) antibody (dianova, Hamburg) diluted 1:5000. The anti-17-1A/anti-CD3 bispecific-single-chain antibody (Mack, Proc. Natl. Acad. Sci. USA 92 (1995) 7021-7025) was used as positive control. As negative control, wells were incubated with phosphate buffered saline. The ELISA was developed by ABTS -substrate solution as described in Example 8. The OD-values were measured at 405nm by an ELISA reader.

Figure 1.5: ELISA-analysis of the cell-culture supernatant obtained from CHO-cells transfected with the expression plasmid pEF-DHFR+CTI+CD80-M79scFv(V<sub>L</sub>/V<sub>H</sub>) including the coding sequence of the short (Gly<sub>4</sub>Ser<sub>1</sub>)<sub>1</sub> linker. 96 well ELISA plates were incubated with 50µl soluble 17-1A antigen (50µg/ml) per well. Subsequently pure cell-culture supernatant and dilutions thereof were added as indicated. Detection was performed by a murine IgG1-anti CD80 antibody diluted 1:1000 followed by a peroxidase conjugated polyclonal goat anti mouse IgG (Fc) antibody (dianova, Hamburg) diluted 1:5000. The anti-17-1A/anti-CD3 bispecific-single-chain antibody (Mack, Proc. Natl. Acad. Sci. USA 92 (1995) 7021-7025). was used as positive control and detected as described in Figure 1.4. As negative control, wells were incubated with phosphate buffered saline. The ELISA was developed by an ABTS -substrate solution as described in Example 8. The OD-values were measured at 405nm by an ELISA reader.

Figure 1.6: ELISA-analysis of the purified recombinant CD80-M79scFv(V<sub>L</sub>/V<sub>H</sub>)-construct with a short (Gly<sub>4</sub>Ser<sub>1</sub>)<sub>1</sub> linker obtained by purification from cell-culture supernatant using a Ni-NTA-column as described (Mack, Proc. Natl. Acad. Sci. USA 92 (1995) 7021-7025). 96 well ELISA plates were coated overnight at 4°C with pure eluate from the Ni-NTA-column and dilutions thereof as indicated. Subsequently bound recombinant protein was detected by a murine IgG1-anti CD80 antibody diluted 1:1000 or by a murine IgG1-anti His-tag antibody (dianova, Hamburg) diluted 1:200 followed by a peroxidase conjugated polyclonal goat anti mouse IgG (Fc) antibody (dianova, Hamburg) respectively diluted 1:5000. As negative control wells were coated overnight at 4°C with 3% BSA in phosphate buffered saline. The ELISA

was developed by an ABTS -substrate solution as described in Example 8. The OD-values were measured at 405nm by an ELISA reader.

Figure 1.7: ELISA-analysis of the cell-culture supernatant obtained from CHO-cells transfected with the expression plasmid pEF-DHFR+CTI+CD80-M79scFv(V<sub>H</sub>/V<sub>L</sub>) including the coding sequence of the short (Gly<sub>4</sub>Ser<sub>1</sub>)<sub>1</sub> linker. 96 well ELISA plates were incubated with soluble 17-1A antigen (50µg/ml) per well. Subsequently pure cell-culture supernatant and dilutions thereof were added as indicated. Detection was performed by a murine IgG1-anti CD80 antibody diluted 1:1000 followed by a peroxidase conjugated polyclonal goat anti-mouse IgG (Fc) antibody (dianova, Hamburg) diluted 1:5000. The anti-17-1A/anti-CD3 bispecific-single-chain antibody (Mack, Proc. Natl. Acad. Sci. USA 92 (1995) 7021-7025) was used as positive control and detected as described in Figure 1.4. As negative control wells were incubated with phosphat buffered saline. The ELISA was processed by an ABTS-substrate solution as described in Example 8. The OD-values were measured at 405nm by an ELISA reader.

Figure 1.8: DNA-sequence of the double-stranded oligonucleotide designated ACCGS15BAM with single-stranded overhangs compatible with those of restriction enzymes BspEI and BamHI. Amino acids encoded by the nucleotide sequence are shown.

Figure 1.9: ELISA-analysis of the cell-culture supernatant and of its dilutions obtained from CHO-cells transfected with the expression plasmid pEF-DHFR+CTI+CD80-M79scFv (V<sub>H</sub>/V<sub>L</sub>) including the coding sequence of the long (Gly<sub>2</sub>Ser<sub>1</sub>)<sub>3</sub> linker. 96 well ELISA plates were incubated with 50µl soluble 17-1A antigen (50µg/ml) per well. Subsequently pure cell-culture supernatant and dilutions thereof were added as indicated. Bound protein was detected by a murine anti His-tag antibody (dianova, Hamburg) diluted 1:200 followed by a peroxidase conjugated polyclonal goat anti mouse IgG (Fc) antibody (dianova, Hamburg) diluted 1:5000. The anti-17-1A/anti-CD3 bispecific-single-chain antibody antibody (Mack, Proc. Natl. Acad. Sci. USA 92 (1995) 7021-7025) was used as positive control. As negative

control wells were incubated with phosphat buffered saline. The ELISA was developed by an ABTS-substrate solution as described in Example 8. The OD-values were measured at 405nm by an ELISA reader.

Figure 2.1: ELISA-analysis of the cell-culture supernatant obtained from CHO-cells transfected with the expression plasmids pEF-DHFR+CTI+CD80-M74scFv(V<sub>H</sub>/V<sub>L</sub>) or pEF-DHFR + CTI + CD80-M74scFv(V<sub>L</sub>/V<sub>H</sub>) including the coding sequence of the long (Gly<sub>4</sub>Ser<sub>1</sub>)<sub>3</sub> or short (Gly<sub>4</sub>Ser<sub>1</sub>)<sub>1</sub> linker respectively. 96 well ELISA plates were incubated with 50µl soluble 17-1A antigen (50µg/ml) per well. Subsequently pure cell-culture supernatant and dilutions thereof were added as indicated. Detection was performed by a murine IgG1 anti His-tag antibody (dianova, Hamburg) diluted 1:1000 and followed by a peroxidase conjugated polyclonal goat anti mouse IgG (Fc) antibody (dianova, Hamburg) diluted 1:5000. The anti-17-1A/antiCD3 bispecific-single-chain antibody antibody (Mack, Proc. Natl. Acad. Sci. USA 92 (1995) 7021-7025) was used as positive control and detected as described in Figure 1.4. As negative control wells were incubated with phosphat buffered saline. The ELISA was developed by an ABTS-substrate solution as described in Example 8. The OD-values were measured at 405nm by an ELISA reader.

Figure 2.2: ELISA-analysis of the cell-culture supernatant obtained from CHO-cells transfected with the expression plasmids pEF-DHFR+CTI+CD80-M74scFv(V<sub>H</sub>/V<sub>L</sub>) or pEF-DHFR + CTI + CD80-M74scFv(V<sub>L</sub>/V<sub>H</sub>) including the coding sequence of the long (Gly<sub>4</sub>Ser<sub>1</sub>)<sub>3</sub> or short (Gly<sub>4</sub>Ser<sub>1</sub>)<sub>1</sub> linker respectively. 96 well ELISA plates were incubated with 50µl soluble 17-1A antigen (50µg/ml) per well. Subsequently pure cell-culture supernatant and dilutions thereof were added as indicated. Detection was performed by a murine IgG1-anti CD80 antibody diluted 1:1000 followed by a peroxidase conjugated polyclonal goat anti mouse IgG (Fc) antibody (dianova, Hamburg) diluted 1:5000. The anti-17-1A/anti-CD3 bispecific-single-chain antibody antibody (Mack, Proc. Natl. Acad. Sci. USA 92 (1995) 7021-7025) was used as positive control and detected as described in Figure 1.4. As negative control wells were incubated with phosphat buffered saline. The ELISA was developed by an

ABTS -substrate solution as described in Example 8. The OD-values were measured at 405nm by an ELISA reader.

Figure 3.1: DNA- and protein sequence of the human D4.5. heavy chain variable region ( $V_H$  of the human anti-17-1A-antibody VD4.5VK8). Number indicate the nucleotide (nt) positions, amino acids are presented in the single letter code. CDR1 includes nt 91 to nt 105, CDR2 nt 148 to nt 198, CDR3 nt 292 to nt 351.

Figure 3.2: DNA- and protein sequence of the human kappa 8 light chain variable region ( $V_L$  of the human anti-17-1A-antibody VD4.5VK8). Numbers indicate the nucleotide (nt) positions, amino acids are presented in single letter code. CDR1 includes nt 70 to nt 102, CDR2 nt 148 to nt 168, CDR3 nt 265 to nt 294.

Figure 3.3: ELISA-analysis of free scFv-fragment ( $V_H/V_L$ ) of the human anti 17-1A antibody VD4.5VK8. The sequence encoding the N2-domain was excised from the plasmid pComb3H5BHis-VD4.5VK8scFv (Example 3) using the restriction enzymes Sall and Xhol followed by religation of the vector. The resulting plasmid was used for periplasmatic expression of soluble VD4.5VK8-scFv-fragment in E.coli XL1-blue according to the procedure described in Example 6. Analysis of binding to the 17-1A-antigen of soluble VD4.5VK8-scFv-fragment was performed as follows: 96 well ELISA plates were incubated with soluble 17-1A antigen (50 $\mu$ g/ml). Subsequently, pure periplasma preparation was added. Detection was performed by a murine IgG1-anti-His-tag antibody diluted 1:250 followed by a peroxidase conjugated polyclonal goat anti mouse IgG (Fc) antibody (dianova, Hamburg) diluted 1:5000. The anti-17-1A/anti-CD3 bispecific-single-chain antibody (Mack, Proc. Natl. Acad. Sci. USA 92 (1995) 7021-7025) was used as positive control and detected as described in Figure 1.4. As negative control, an irrelevant periplasma preparation was used. The ELISA was developed by an ABTS -substrate solution as described in Example 8. The OD-values were measured at 405nm by an ELISA reader.

Figure 3.4: NS3 Frame: DNA-sequence designated L-F-NS3Frame that was cloned into the multicloning site of the vector Bluescript-KS-CTI (Figure1.2) by using the

restriction sites EcoRI and Sall in order to increase the number of possible cloning sites. Cloning sites derived from L-F-NS3Frame are shown.

Figure 4: ELISA-analysis of the cell-culture supernatant obtained from CHO-cells transfected with the light and heavy chain of the chimerized anti 17-1A antibody MACH (Example 4). 96 well ELISA plates were incubated with soluble 17-1A antigen (50µg/ml). Subsequently, pure cell-culture supernatant and dilutions thereof were added as indicated. Detection was performed by a biotinylated anti human IgG antibody followed by streptavidin. Supernatant of the parent murine anti-17-1A antibody MACH and dilutions thereof were used as positive control and detected by a biotinylated anti-mouse IgG antibody. As negative control, phosphat buffered saline was used. The ELISA was developed by an ABTS -substrate solution as described in Example 8. The OD-values were measured at 405nm by an ELISA reader.

Figure 5.1: Cloning site of pComb3H with important restriction sites. The following abbreviations were used: P, lac-promotor;  $V_L$ , variable light chain domain; CL, constant light chain domain;  $V_H$ , variable heavy chain domain; CH1, constant heavy chain domain; L1/2, procaryotic leader sequences (L1 = ompA, L2 = pelB).

Figure 5.2: DNA sequence of the multiple cloning site of pComb3H5BHIS showing important restriction enzyme cleavage sites as well as the amino acid sequence of the Glycine-Serine-linker and that of the N2-domain of the gene III-product of filamentous phage.

The DNA-sequence encoding the N2-domain starts at nt 19 and ends at nt 411.

Figure 5.3: Cloning site of pComb3H5BHIS with important restriction sites. The following abbreviations were used: P, lac-promotor;  $V_K$ , variable kappa light chain domain;  $V_H$ , variable heavy chain domain; ompA, procaryotic leader sequence; N2 is linked to  $V_H$  by a Gly<sub>4</sub>Ser<sub>1</sub>-linker;  $V_H$  is linked to  $V_K$  by a (Gly<sub>4</sub>Ser<sub>1</sub>)<sub>3</sub>-linker.

Figure 6.1: Scheme of the pComb3H5BHIS-plasmid and the fully expressed M13-phage. At the top the organization of leader (L) ompA,  $V_H$ ,  $V_K$  and gene III is shown.

A representative expressed M13-phage-particle (bottom) displays on its surface the phenotype of a certain scFv-fragment consisting of  $V_H$  and  $V_K$  linked with its C-terminus to the gene III product and with its N-terminus in the N2-domain and contains the corresponding genotype as single-stranded DNA encoding said protein elements as a single polypeptide chain.

Figure 6.2: ELISA-analysis of 17-1A-specific scFv protein fragments generated by the method of invention. Periplasma preparations of soluble scFv protein fragments containing the N2-domain at their N-terminus and consisting of one single mouse  $V_{\kappa}$ - and one single  $V_{\text{heavy}}$  chain-domain, respectively were added pure to an ELISA-plate that had been coated with soluble 17-1A antigen. Detection was performed by a murine IgG1 anti-his-tag antibody followed by a peroxidase conjugated polyclonal goat anti mouse-Ig(Fc) antibody. The ELISA was developed by an ABTS-substrate solution as described in Example 8. The OD-values (y-axis) were measured at 405 nm by an ELISA-reader. Clones are presented on the x-axis, the lower number indicates the round of panning, the number above indicates the tested clone of this round. Clones 0-1 to 0-9 have a combination of unselected scFv-fragments and therefore can be seen as negative controls. the positive control is an anti 17-1A / anti-CD3 bispecific single chain Fv antibody (Mack, Proc. Natl. Acad. Sci. USA 92 (1995) 7021-7025).

Figure 6.3: DNA- and protein-sequence of the mouse scFv fragment 3-1. Numbers indicate the nucleotide (nt) positions, amino acids (aa) are presented in single letter code. The first four aa of the  $V_H$ -fragment are encoded by the plasmid pComb3H5BHis. The encoding DNA sequence for the V-region of the heavy chain starts at nt 1 and ends at nt 360 followed by a  $(G_4S_1)_3$ -linker. The coding DNA sequence for the V-region of the kappa chain starts at nt 406 and ends at nt 726.

Figure 6.4: DNA- and protein-sequence of the mouse scFv fragment 3-5. Numbers indicate the nucleotide (nt) positions, amino acids (aa) are presented in single letter code. The first four aa of the  $V_H$ -fragment are encoded by the plasmid pComb3H5BHis. The encoding DNA sequence for the V-region of the heavy chain

starts at nt 1 and ends at nt 372 followed by a  $(G_4S_1)_3$ -linker. The coding DNA sequence for the V-region of the kappa chain starts at nt 418 and ends at nt 753.

Figure 6.5: DNA- and protein-sequence of the mouse scFv fragment 3-8. Numbers indicate the nucleotide (nt) positions, amino acids (aa) are presented in single letter code. The first four aa of the  $V_H$ -fragment are encoded by the plasmid pComb3H5BHIs. The encoding DNA sequence for the V-region of the heavy chain starts at nt 1 and ends at nt 360 followed by a  $(G_4S_1)_3$ -linker. The coding DNA sequence for the V-region of the kappa chain starts at nt 406 and ends at nt 726.

Figure 6.6: DNA- and protein-sequence of the mouse scFv fragment 4-1. Numbers indicate the nucleotide (nt) positions, amino acids (aa) are presented in single letter code. The first four aa of the  $V_H$ -fragment are encoded by the plasmid pComb3H5BHIs. The encoding DNA sequence for the V-region of the heavy chain starts at nt 1 and ends at nt 360 followed by a  $(G_4S_1)_3$ -linker. The coding DNA sequence for the V-region of the kappa chain starts at nt 406 and ends at nt 744.

Figure 6.7: DNA- and protein-sequence of the mouse scFv fragment 4-4. Numbers indicate the nucleotide (nt) positions, amino acids (aa) are presented in single letter code. The first four aa of the  $V_H$ -fragment are encoded by the plasmid pComb3H5BHIs. The encoding DNA sequence for the V-region of the heavy chain starts at nt 1 and ends at nt 360 followed by a  $(G_4S_1)_3$ -linker. The coding DNA sequence for the V-region of the kappa chain starts at nt 406 and ends at nt 726.

Figure 6.8: DNA- and protein-sequence of the mouse scFv fragment 4-7. Numbers indicate the nucleotide (nt) positions, amino acids (aa) are presented in single letter code. The first four aa of the  $V_H$ -fragment are encoded by the plasmid pComb3H5BHIs. The encoding DNA sequence for the V-region of the heavy chain starts at nt 1 and ends at nt 372 followed by a  $(G_4S_1)_3$ -linker. The coding DNA sequence for the V-region of the kappa chain starts at nt 417 and ends at nt 753.

Figure 6.9: DNA- and protein-sequence of the mouse scFv fragment 5-3. Numbers indicate the nucleotide (nt) positions, amino acids (aa) are presented in single letter code. The first four aa of the  $V_H$ -fragment are encoded by the plasmid pComb3H5BHis. The encoding DNA sequence for the V-region of the heavy chain starts at nt 1 and ends at nt 348 followed by a  $(G_4S_1)_3$ -linker. The coding DNA sequence for the V-region of the kappa chain starts at nt 394 and ends at nt 717.

Figure 6.10: DNA- and protein-sequence of the mouse scFv fragment 5-10. Numbers indicate the nucleotide (nt) positions, amino acids (aa) are presented in single letter code. The first four aa of the  $V_H$ -fragment are encoded by the plasmid pComb3H5BHis. The encoding DNA sequence for the V-region of the heavy chain starts at nt 1 and ends at nt 360 followed by a  $(G_4S_1)_3$ -linker. The coding DNA sequence for the V-region of the kappa chain starts at nt 406 and ends at nt 744.

Figure 7: DNA- and protein-sequence of the mouse scFv fragment 5-13. Numbers indicate the nucleotide (nt) positions, amino acids (aa) are presented in single letter code. The first four aa of the  $V_H$ -fragment are encoded by the plasmid pComb3H5BHis. The encoding DNA sequence for the V-region of the heavy chain starts at nt 1 and ends at nt 360 followed by a  $(G_4S_1)_3$ -linker. The coding DNA sequence for the V-region of the kappa chain starts at nt 406 and ends at nt 744.

Figure 8.1: ELISA analysis of nine cell-culture supernatants (primary selection step (PS)) obtained from CHO cells transfected with the expression plasmids pEF-DHFR + CTI + CD80 + scFv 17-1A clones 3-1 to 5-13. 96 well U bottom ELISA plates were incubated with 50  $\mu$ l of soluble 17-1A antigen (50 $\mu$ g/ml) per well. Antibody constructs as culture supernatants were added pure and at following dilutions: 1:2, 1:4, 1:8. Detection was performed by a CD80-specific monoclonal antibody diluted 1:1000 in PBS 1%BSA followed by a polyclonal peroxidase-conjugated Goat Anti-Mouse IgG-antibody (Fc-specific) (dianova, Hamburg) diluted 1:5000. The ELISA was finally developed by adding the ABTS substrate solution as described in Example 8. For negative controls, the plates were incubated with PBS instead of

bifunctional antibody constructs. The OD-values were measured by an ELISA reader at 405 nm.

Figure 8.2: ELISA analysis of nine cell-culture supernatants (1. Amplification step (20 nM MTX) (1. Amp)) obtained from CHO cells transfected with the expression plasmids pEF-DHFR + CTI + CD80 + scFV 17-1A clones 3-1 to 5-13. 96 well U bottom ELISA plates were incubated with 50 µl of soluble 17-1A antigen (50µg/ml) per well. Antibody constructs as culture supernatants were added pure and at following dilutions: 1:2, 1:4, 1:8. Detection was performed by a CD80-specific monoclonal antibody diluted 1:1000 in PBS 1% BSA followed by a polyclonal peroxidase-conjugated Goat Anti-Mouse IgG-antibody (Fc-specific) (dianova, Hamburg) diluted 1:5000. The ELISA was finally developed by adding the ABTS substrate solution as described in Example 8. For negative controls, the plates were incubated with PBS instead of bifunctional antibody constructs. The OD-values were measured by an ELISA reader at 405 nm.

Figure 8.3: ELISA analysis of two cell-culture supernatants (primary selection step (PS)) from 17-1A specific bifunctional CD80-scFv-constructs, which were generated as described in Example 3 and 4. 96 well U bottom ELISA plates were incubated with 50 µl of soluble 17-1A antigen (50µg/ml) per well. Antibody constructs as culture supernatants were added pure and at following dilutions: 1:2, 1:4, 1:8. Detection was performed by a CD80-specific monoclonal antibody diluted 1:1000 in PBS 1% BSA followed by a polyclonal peroxidase-conjugated Goat Anti-Mouse IgG-antibody (Fc-specific) (dianova, Hamburg) diluted 1:5000. The ELISA was finally developed by adding the ABTS substrate as described in Example 8. For negative controls, the plates were incubated with PBS instead of bifunctional antibody constructs. As positive control served a supernatant generated in Example 7. The OD-values were measured at 405 nm using an ELISA-reader.

Figure 8.4: ELISA analysis of two cell-culture supernatants (1. Amplification step (20 nM MTX) (1. Amp)) from 17-1A specific bifunctional CD80-scFv-constructs, which were generated as described in Example 3 and 4. 96 well U bottom ELISA plates

were incubated with 50 µl of soluble 17-1A antigen (50µg/ml) per well. Antibody constructs as culture supernatants were added pure and at following dilutions: 1:2, 1:4, 1:8. Detection was performed by a CD80-specific monoclonal antibody diluted 1:1000 in PBS 1%BSA followed by a polyclonal peroxidase-conjugated Goat Anti-Mouse IgG-antibody (Fc-specific) (dianova, Hamburg) diluted 1:5000. The ELISA was finally developed by adding the ABTS substrate solution as described in Example 8. For negative controls, the plates were incubated with PBS instead of bifunctional antibody constructs. As positive control a supernatant generated in Example 7 was used. The OD-values were measured at 405 nm using an ELISA-reader.

Figure 9.1: Binding studies of 17-1A specific bifunctional CD80-scFv-constructs on 17-1A transfected (filled lines) and untransfected CHO cells (broken lines) detected by flow cytometry.  $5 \times 10^5$  cells were incubated in 50 µl undiluted cell-culture supernatant containing the corresponding bifunctional construct. Bound bifunctional CD80-scFv-constructs were detected by a monoclonal anti-CD80 antibody (Immunotech. Cat. No.: 1449) diluted 1:20 in 50 µl PBS. Incubation conditions were the same as described in Figure 8.5. Bound CD80-antibody was finally detected by a fluorescein conjugated polyclonal Goat Anti-Mouse IgG + IgM (H+L) antibody diluted 1:100 in PBS. Incubation was again carried out for 30 minutes on ice. For the fixation of fluorescein-labeled cells 1% paraformaldehyd in PBS was used. As first negative control untransfected CHO was used. The second negative control contained 17-1A-transfected cells that were incubated with PBS instead of bifunctional CD80-scFv-constructs. Cells were analysed by flow cytometry on a FACS scan (Becton Dickenson).

Figure 9.2: FACS-Control of the CHO cells after transfection with 17-1A. The expression of transmembrane 17-1A was increased by stepwise gene amplification induced by subsequent addition of increasing concentrations of the DHFR inhibitor MTX to a final concentration of 500nM, with the concentration steps in between 20nM and 100nM. These cells were tested for membrane expression of 17-1A by flow cytometry at a concentration of 10µg/ml of the 17-1A-specific antibody

M79 (Göttlinger, Int. J. Cancer 38 (1986), 47-53) followed by a FITC-labeled polyclonal Goat Anti Mouse IgG + IgM (H+L) antibody diluted 1:100 in PBS. As negative control untransfected CHO cells were used whereas the 17-1A-positive human gastric cancer cell-line Kato, obtained from ATCC served as positive control.

Figure 10: Principle of constructing bifunctional single-chain proteins

Figure 11: Structural comparison between wildtype phage, conventional phage display and phage display according to the method of the invention.

Figure 12: ELISA –analysis of cell-culture supernatants of different anti 17-1A-CD54-, anti 17-1A- CD58- and anti 17-1A- CD86-scFv constructs with varying anti 17-1A specificities (4-7, 5-3, 5-10) obtained by the method of the invention. Cell-culture supernatant of transfected CHO-cells subjected to one step of gene amplification (20nM MTX, see Example 10) was incubated in several dilutions in 96-well U bottom ELISA plates with immobilized 17-1A antigen (Coating conditions: see Example 8) Specific detection of the different constructs bound to immobilized 17-1A antigen was performed by using an anti-CD54-(Immunotech Hamburg, Cat.no 0544), an anti-CD58-(Immunotech, Hamburg Cat.no.0861), or an anti-CD86-(R&D Systems, Cat.No. MB141) antibody (diluted 1:1000), followed by a polyclonal peroxidase-conjugated Goat Anti-Mouse IgG-antibody (Fc-specific) diluted 1:5000, respectively. The ELISA was finally developed by adding an ABTS substrate solution as described in Example 8. For negative controls, the plates were incubated with PBS instead of bifunctional antibody constructs. The OD-values were measured at 405nm using an ELISA-reader.

Tab. 1: Primer sets for the amplification of the V<sub>H</sub>- and VK-DNA-fragments (5' to 3')

The following Examples illustrate the invention:

**Example 1: CD80-M79scFv constructs****1.1 CD80 - M79 scFv (V<sub>L</sub>/V<sub>H</sub>) construct with short (Gly<sub>4</sub>Ser<sub>1</sub>)<sub>1</sub> linker**

A protein was constructed that consists of the single-chain Fv fragment (scFv) of the murine anti 17-1A antibody M79 and the extracellular part of the human costimulatory protein CD80 (B7-1) connected by a (Gly<sub>4</sub>Ser<sub>1</sub>)<sub>1</sub> linker (Figure 1.1). The M79 antibody was obtained as described by Göttlinger (1986) Int.J.Cancer:38, 47-53. The M79 scFv fragment was cloned as described by Mack. Proc. Natl. Acad. Sci. U.S.A.. 92 (1995) 7021-7025. The complete plasmid was cloned in several steps. First a poly-linker designated CTI was inserted into the Bluescript KS vector (GenBank® accession number X52327) using the restriction enzyme cleavage sites XbaI and SalI (Boehringer Mannheim). The introduction of the polylinker CTI provided additional cleavage sites as well as the sequence encoding the (Gly<sub>4</sub>Ser<sub>1</sub>)<sub>1</sub> linker a six-amino acid histidine tag and a stop codon as shown in Figure 1.2..The vector Bluescript KS + CTI was prepared by cleavage with the restriction enzymes EcoRV and XmaI (Boehringer Mannheim and New England Biolabs) in order to ligate it (T4 DNA, Ligase Boehringer Mannheim) with the M79 scFv fragment cleaved by EcoRV and BspEI (New England Biolabs). The resulting vector Bluescript KS+CTI+M79 scFv again was cleaved with EcoRI (Boehringer Mannheim) and BspEI in order to insert the CD80 DNA-fragment which was previously prepared using the same enzymes. Prior to subcloning, the CD80 fragment was obtained by polymerase chain reaction (PCR) using specific oligonucleotide primers complementary to the 5' and 3' ends of the nucleotide sequence encoding the extracellular part of CD80 (Freeman G.J et.al. J.Immunol.143,(1989) 2714 - 2722.). These primers also introduced an EcoRI and a BspEI cleavage site (5'CD80 Primer: 5'GCA GAA TTC ACC ATG GGC CAC ACA CGG AGG CAG 3'; 3'CD80 Primer: 5'TGG TCC GGA GTT ATC AGG AAA ATG CTC TTG CTT G 3') The cDNA template used for this PCR was prepared by reverse transcription of the total RNA prepared from the Burkitt-lymphoma cell line Raji according to standard procedures (Sambrook, Molecular Cloning; A Laboratory Manual, 2<sup>nd</sup> Edition, Cold Spring Harbour Laboratory Press, cold Spring Habour, New York (1989)).

The CD80 costimulatory protein belongs to the Ig superfamily. It is a heavily glycosylated protein of 262 amino acids. A more detailed description was published by Freeman G.J et.al. J.Immunol.143,(1989) 2714 - 2722.

In the last step, the whole CD80-M79scFv ( $V_L/V_H$ ) DNA fragment (Figure 1.3.1.) was isolated by cleaving the vector Bluescript KS+CTI+CD80-M79scFv ( $V_L/V_H$ ) with EcoRI and Sall (Boehringer Mannheim) and subsequently introduced into the eukaryontic expression vector pEF-DHFR described in Mack et.al. Proc. Natl. Sci. U.S.A. 92 (1995) 7021-7025 containing the dihydrofolatereductase gene as selection marker. The final plasmid was linearized with the restriction enzyme NdeI (Boehringer Mannheim) and transfected into CHO cells by electroporation. The electroporation conditions were 260V/960 $\mu$ FD using a BioRad Gene Pulser™. Stable expression was performed in DHFR deficient CHO-cells as described by Kaufmann R.J. (1990) Methods Enzymol. 185, 537-566. The cells were grown for selection in nucleoside free  $\alpha$ -MEM medium supplemented with 10% dialysed FCS and 2 mM L-glutamine. For production of the bifunctional CD80-M79 scFv ( $V_L/V_H$ ) construct, cells were grown in rollerbottles (Falcon) for 7 days in 300ml culture medium. The protein was purified via its His-tag attached to the C-terminus (see Figure 1.1.) by using a Ni-NTA-column (Mack et.al., Proc. Natl. Acad. Sci. U.S.A. 92 (1995)7021-7025). To analyse the binding properties different ELISA assay were performed:

### **1.1.1 ELISA with cell culture supernatant using anti-His-tag detection**

Binding to the 17-1A-antigen was analysed using soluble 17-1A-antigen obtained as described (Mack, Proc. Natl. Acad. Sci. U.S.A. 92 (1995) 7021-7025) by stable expression in CHO-cells of the DNA encoding the first 264 amino acids of the 17-1A antigen also known as GA 733-2 (Szala, Proc. Natl. Acad. Sci. U.S.A. 87 (1990) 3542-3546) followed by a stop codon.. The antigen was immobilized on 96 well U bottom ELISA plates (nunc maxisorb) at a concentration of 50 $\mu$ g/ml phosphat buffered saline PBS. Coating was carried out at 4°C for 12 hours with 50 $\mu$ l followed by washing once with (PBS) 0,05%Tween. The ELISA was then blocked for 1 hour

with PBS/3%bovine serum albumin (BSA) and washed again once. Now the cell-culture supernatant was added undiluted and at several dilutions and incubated for 2 hours. As detection system a murine IgG1 anti His-tag antibody (dianova, Hamburg) diluted 1:200 and a peroxidase conjugated polyclonal goat anti mouse IgG (Fc) (dianova, Hamburg) antibody were applied sequentially. The ELISA was developed by adding ABTS-substrate solution (2'2 Azino-bis (3-Ethylbenzthiazoline-6-Sulfonic Acid), SIGMA A-1888, Steinheim) as described in Example 8. The result was measured by an ELISA-Reader at OD 405 nm; results are shown in Figure 1.4. Obviously no binding activity could be measured. As negative controls, the plates were incubated with PBS instead of antibody constructs. As positive control served the anti-17-1A/anti-CD3 bispecific-single-chain antibody described previously (Mack, Proc. Natl. Acad. Sci. U.S.A. 92 (1995) 7021-7025).

### **1.1.2 ELISA with cell culture supernatant using anti-CD80 detection**

Immobilization of 17-1A-antigen, blocking and the incubation of cell culture supernatants was performed as described above. Detection was carried out with a murine IgG1 anti-CD80-antibody diluted 1:1000 (dianova, Hamburg) followed by a peroxidase conjugated polyclonal goat anti-mouse IgG (Fc)-antibody diluted 1:5000 (dianova, Hamburg). The ELISA was developed with ABTS-substrat solution and OD-values were measured as described above, however, again no 17-1A-binding activity could be detected. As positive control, the anti-17-1A/anti-CD3 bispecific-single-chain antibody (Mack, Proc. Natl. Acad. Sci. U.S.A. 92 (1995) 7021-7025) was used and detected with the described anti-His-tag antibody. Results are shown in Figure 1.5

### **1.1.3 ELISA-analysis of purified recombinant CD 80-M79scFv-construct**

As the ELISAs with cell-culture supernatants detecting specific antigen binding were all negative, soluble CD80-M79scFv was obtained by protein purification from supernatant of a roller bottle culture (300ml) in order to exclude the possibility that no recombinant protein was secreted into the supernatant. The purification was

carried out using a Nickel-NTA-column as described (Mack, Proc. Natl. Acad. Sci. U.S.A. 92 (1995) 7021-7025). ELISA wells were coated with the protein eluted from the Nickel-NTA-column. Detection of the bifunctional CD80-M79scFv-construct was performed independently of its 17-1A-antigen binding activity by using either an anti His-tag antibody (see Example 1.1.1.) as well as an anti-CD80 antibody (see Example 1.1.2.) in separate experiments followed by an anti-mouse IgG(Fc) antibody, respectively. Development of the ELISA as well as the measurement of the OD-values was carried out as described above. The results are shown in Figure 1.6., confirming the presence of the CD80-M79scFv-construct in the cell culture supernatant.

## 1.2 CD80 - M79 scFv ( $V_H/V_L$ ) construct with ( $Gly_4Ser_1$ )<sub>1</sub> linker

To change the arrangement of the Ig variable regions within the M79scFv fragment from  $V_L/V_H$  to  $V_H/V_L$  a two step fusion PCR using oligonucleotide primers 5'  $V_H$ B5RRV:AGG TGT ACA CTC CGA TAT C(A,C)A (A,G)CT GCA G(G,C)A GTC (A;T)GG, 3'  $V_H$ GS15, 5'  $V_L$ GS15 ,3'  $V_L$ BspE1 (for sequences of the three last oligonucleotides see Example 2.1) was performed according to the procedure described by Mack, Proc. Natl. Acad. Sci. U.S.A. 92 (1995) 7021-7025 (see also Example 2.1.) The PCR-fragment encoding the  $V_H/V_L$ -scFv-fragment was cleaved with the restriction enzymes EcoRV/BspEI and inserted into the vector Bluescript KS + CTI already prepared by cleavage with EcoRV/XmaI (see Example 1.1.). Next, the inverted M79scFv ( $V_H/V_L$ ) fragment was excised with the restriction enzymes BspEI/Sall and introduced into the plasmid pEF-DHFR+CTI + CD80-M79scFv ( $V_L/V_H$ ) using BspEI/Sall thus replacing the M79scFv-  $V_L/V_H$  fragment (see Figure 1.3.2.). Transfection and cell culture procedures were carried out as described above. Analysis of antigen binding was performed using the described 17-1A-ELISA (Example 1.1.2.). However, no 17-1A binding activity of the alternatively arranged CD80-M79scFv-construct could be detected. Results are shown in Figure 1.7.

### 1.3 CD80 - M79 scFv ( $V_H/V_L$ ) construct with a long ( $Gly_4Ser_1)_3$ linker

First, the M79scFv ( $V_H/V_L$ ) fragment was obtained by a two step fusion PCR as described in Example 1.2. The PCR fragment encoding the  $V_H/V_L$ -scFv-fragment was cleaved with the restriction enzymes EcoRV/BspEI and subcloned into the Bluescript KS +CTI vector cleaved EcoRV/XmaI (see Example 1.1). In a further step a longer Glyin-Serin linker ( $Gly_4Ser_1)_3$  consisting of 15 amino acids was introduced. Therefore, another oligonucleotide linker (ACCGS15BAM), which was designed to encode the ( $Gly_4Ser_1)_3$  linker and to provide BspEI and BamHI compatible overhangs had to be inserted into the Bluescript KS + CTI + M79 scFv ( $V_H/V_L$ ) (Example 1.2). The nucleotide sequence of the linker is shown in Figure 1.8.

The plasmid Bluescript KS + CTI + M79 scFv ( $V_H/V_L$ ) including the coding sequence of the ( $Gly_4Ser_1)_3$  linker was cleaved with BspEI and Sall and the resulting DNA-fragment ( $Gly_4Ser_1)_3+M79scFv (V_H/V_L)$  was inserted into the BspEI/Sall-cleaved vector pEF-DHFR that contains the CD80-coding fragment (Example 1.1) thus replacing the M79scFv ( $V_L/V_H$ ) fragment together with the short ( $Gly_4Ser_1)_1$  linker (see Figure 1.3.3). For transfection and cell culture procedure see Example 1.1. Antigen specific binding was analysed by 17-1A ELISA as described above (Example 1.1.1) and detection of functional recombinant protein in the cell-culture supernatant was performed with an anti His-tag antibody followed by an anti mouse IgG (Fc) antibody (compare Example 1.1.1). The anti-17-1A/anti-CD3 bispecific-single-chain antibody (Mack, Proc. Natl. Acad. Sci. U.S.A. 92 (1995) 7021-7025) served as positive control. Development of the ELISA and measurement of the OD values was carried out as described above (Example 1.1.1). However, no antigen binding was detectable. Results are shown in Figure 1.9.

**Example 2:** CD80 - M74 scFv construct with either short ( $\text{Gly}_4\text{Ser}_1$ )<sub>1</sub> or long ( $\text{Gly}_4\text{Ser}_1$ )<sub>3</sub> linker as well as ( $V_H/V_L$ ) or ( $V_L/V_H$ )-domain arrangement

A protein was constructed that consists of the single-chain Fv fragment (scFv) of the anti 17-1A antibody M74 and the costimulatory protein CD80 connected by a ( $\text{Gly}_4\text{Ser}_1$ ) linker (Figure 1.1). The M74 antibody was obtained as described by Göttlinger (1986) Int. J. Cancer: 38, 47-53.  $V_L$  and  $V_H$  of M74 were cloned from the total RNA of the corresponding hybridoma cell line as described by Orlandi (1989) Proc. Natl. Acad. Sci. USA 86, 3833-3837 and sequenced. The plasmids containing  $V_L$  and  $V_H$  of the M74 antibody respectively were used as templates for a two-step fusions-PCR resulting in M74 scFv-fragments with either the domain arrangement  $V_L/V_H$  or the alternative arrangement  $V_H/V_L$ . Regarding the  $V_L/V_H$  arrangement, the primers for M74  $V_L$  were 5'V<sub>L</sub>B5RRV (5'AGG TGT ACA CTC CGA TAT CCA GCT GAC CCA GTC TCC A3') and 3'V<sub>L</sub>GS15 (5'GGA GCC GCC GCC GCC AGA ACC ACC ACC ACC TTT GAT CTC GAG CTT GGT CCC3'), for M74  $V_H$  5'M74V<sub>H</sub>GS15 (5'GGC GGC GGC TCC GGT GGT GGT TCT CAG GT(GC) (AC)A(AG) CTG CAG (GC)AG TC(AT) GGA CCT GAG CTG GTG AAG CCT GGG GCT TCA GTG AAG ATT TCC TGC 3') and 3'V<sub>H</sub>BspEI (5'AAT CCG GAG GAG ACG GTG ACC GTG GTC CCT TGG CCC CAG3'). Regarding the  $V_H/V_L$ -arrangement the primers for M74  $V_H$  were 5'M74V<sub>H</sub>EcoRV (5'TCC GAT ATC (AC)A(AG) CTG CAG (GC)AG TC(AT) GGA CCT GAG CTG GTG AAG CCT GGG GCT TCA GTG AAG ATT TCC TGC 3') and 3'V<sub>H</sub>GS15 (5'GGA GCC GCC GCC AGA ACC ACC ACC ACC TGA GGA GAC GGT GAC CGT GGT CCC TTG GCC CCA G 3'), for M74  $V_L$  5'V<sub>L</sub>GS15 (5'GGC GGC GGC TCC GGT GGT GGT TCT GAC ATT CAG CTG ACC CAG TCT CCA3') and 3'V<sub>L</sub>BspEI (5'AAT CCG GAT TTG ATC TCG AGC TTG GTC CC3'). In the first PCR step the corresponding  $V_H$ -and- $V_L$  fragments were obtained using the following PCR-program: denaturation at 94 °C for 5 min., annealing at 37°C for 2 min., elongation at 72°C for 1 min. for the first cycle; denaturation at 94°C for 1 min., annealing at 37°C for 2 min., elongation at 72°C for 1 min. for 6 cycles; denaturation at 94°C for 1 min., annealing at 55°C for 1 min., elongation at 72°C for 45 sec and 18 cycles ; terminal extension at 72°C for 2 min.).

The purified PCR-fragments of  $V_H$  and  $V_L$  were then used for the second step of the fusion PCR using the following primers for M74 scFv  $V_L/V_H$ : 5'  $V_L$ B5RRV and 3'  $V_H$  BspEI, as well as 5' M74 $V_H$ EcoRV and 3'  $V_L$ BspEI for M74 scFV  $V_H/V_L$ . The following PCR-program was used: denaturation at 94°C for 5 min. once; denaturation at 94°C for 1 min., annealing at 55°C for 1 min., elongation at 72°C for 1:30 min. and 8 cycles; terminal extension at 72°C for 2 min.). The next step was to clone both M74 scFv sequences into the plasmid Bluescript KS+CTI (see Example 1) by cleaving the fragments with EcoRV/BspEI and the vector with EcoRV/XmaI. To obtain constructs with different linker length, the following strategy was used :

For generating the CD80-M74scFv-construct with the  $V_H/V_L$ -and the  $V_L/V_H$ -arrangement respectively and a short ( $Gly_4Ser_1)_1$  linker, the M74 scFv fragment ( $V_H/V_L$ ) as well as the M74 scFv fragment ( $V_L/V_H$ ) were excised from Bluescript KS+CTI respectively and each inserted into the vector pEF-DHFR+CTI+ CD80-M79scFv( $V_L/V_H$ ) (see Example 1.1) using the restriction enzymes BspEI and Sall (see Figure 1.3.4 and 1.3.5). For the transfection in CHO-cells and the cell-culture conditions see Example 1.1.

For generating the CD80-M74 scFv-construct with the  $V_H/V_L$ -and the  $V_L/V_H$ -arrangement respectively, each containing a long ( $Gly_4Ser_1)_3$  linker, the M74 scFv fragments were excised from the vector Bluescript KS+CTI as described above and introduced into the plasmid Bluescript KS + CTI + M79scFv ( $V_H/V_L$ ) including the long linker (see Example 1.3) by cleaving vector and fragments with EcoRV and Sall respectively thereby replacing the M79 specificity with M74 ( $V_H/V_L$ ) or M74 ( $V_L/V_H$ ). The last step prior to transfection was to introduce M74 ( $V_H/V_L$ ) or M74 ( $V_L/V_H$ ) into the pEF-DHFR + CTI + CD80-M79scFv ( $V_H/V_L$ ) vector respectively using the restriction enzymes BspEI and Sall (see Figure 1.3.6 and 1.3.7) thus resulting in plasmids with all the requirements for the expression in CHO-cells of CD80-M74 scFv-constructs either with the  $V_H/V_L$ -or the  $V_L/V_H$ -domain arrangement and a long ( $Gly_4Ser_1)_3$  linker, respectively. For the transfection in CHO-cells and the cell-culture conditions see Example 1.1. The four different constructs (CD80 -( $Gly_4Ser_1)_1$  - M74 ( $V_H/V_L$ ), CD80 -( $Gly_4Ser_1)_1$  - M74 ( $V_L/V_H$ ), CD80 -( $Gly_4Ser_1)_3$  - M74 ( $V_H/V_L$ ), CD80 -

(Gly<sub>4</sub>Ser<sub>1</sub>)<sub>3</sub>- M74 (V<sub>L</sub>/V<sub>H</sub>) ) were all tested for binding to the 17-1A-antigen using cell-culture supernatants as well as purified from culture supernatant using Nickel-NTA-columns as described in Example 1.1.1 and 1.1.3 respectively. The ELISA was performed as described and detection was carried out by using either an anti His-tag antibody or an anti CD80 antibody followed by a peroxidase conjugated anti-mouse-IgG (Fc) antibody (see Example 1.1.1) respectively. Despite the fact that recombinant protein could be purified from all four supernatants (data not shown), no binding to the 17-1A-antigen could be detected as shown in Figure 2.1 and 2.2.

**Example 3: CD80 - VD4.5VK8 scFv(V<sub>H</sub>/V<sub>L</sub>) construct with short (Gly<sub>4</sub>Ser<sub>1</sub>)<sub>1</sub> linker**

In a further Example a human anti-17-1A antibody (VD4.5VK8) selected in vitro by the phage display method from a combinatorial antibody library was chosen to analyse its antigen-binding activity at the C-Terminus of a bifunctional single-chain construct as in Examples 1, 2 and 4 and as illustrated in Figure 1.1. The V<sub>H</sub>-and V<sub>L</sub>-chain of VD4.5VK8 were available in the form of cloned DNA fragments with known nucleotide sequence (Figure 3.1 and 3.2) and served as template molecules for PCR using the following primers: for V<sub>H</sub>: 5'V<sub>H</sub>1357 5'-AGG TGC AGC TGC TCG AGT CTG G-3, and 3'huV<sub>H</sub>BstEII 5'-CTG AGG AGA CGG TGA CC'-3; for V<sub>L</sub>: 5'VK3 GAG CCG CAC GAG CCC GAG CTC GTG (AT)TG AC(AG) CAG TCT CC-3', and 3'huV<sub>k</sub>BsiWI/SpeI 5'-GAA GAC ACT AGT TGC AGC CAC CGT ACG TTT (AG)AT-3'). The V<sub>H</sub>-respectively V<sub>L</sub>-chains were introduced into a newly constructed vector designated pComb3H5BHis and described in Example 5. VD4.5VK8 V<sub>H</sub> was subcloned with Xhol and Bst EII, VD4.5VK8 V<sub>L</sub> with SacI and SpeI resulting in the plasmid: pCOMB3H5BHis+VD4.5VK8 V<sub>H</sub>+V<sub>L</sub>. By using the pComb3H5BHis-vector a fusion PCR was no longer necessary to obtain a scFv-antibody fragment with the domain arrangement V<sub>H</sub>/V<sub>L</sub>.

To analyse the 17-1A-binding activity of the VD4.5VK8 scFv-fragment the N2 fragment (see Example 5) was excised by the restriction enzymes Xhol and Sall. The compatible vector ends were religated; the ligation product was transformed into E.coli XI 1 Blue and periplasmatic protein expression was induced by adding IPTG.

Periplasma preparation was carried out and the resulting sample was directly used for the ELISA-based analysis of 17-1A antigen binding activity as described in Example 5. The wells were coated with soluble 17-1A and bound scFv fragments were detected with a murine anti His-tag antibody diluted 1:200 followed by an anti-mouse IgG (Fc) antibody (see Example 1.1.1) diluted 1:5000. Development of the ELISA and measurement of the OD-values was performed as described in Example 1.1.1. As positive control anti 17-1A antibody clone 3-5 obtained by the method of the invention was used (see Example 6). The results are shown in Figure 3.3 and reveal significant binding of the free monovalent VD4.5.VK8 scFv-fragment to immobilized 17-1A antigen. The next step in generating the bifunctional CD80-VD4.5VK8-scFv-construct was to cleave the plasmid designated Bluescript KS + CTI+L-F-NS3 Frame, deleted of the Bluescript-derived NotI-site and containing an extended polylinker (for the sequence see Figure 3.4), by the enzymes EcoRI and NotI to subclone the EcoRI/NotI VD4.5VK8 fragment from vector pCOMB3H5BHis+VD4.5VK8 V<sub>H</sub>+V<sub>L</sub> described above.

As the last step in generating the bifunctional CD80-VD4.5VK8-scFv-construct, the VD4.5VK8- scFv-fragment was excised from the vector Bluescript KS+CTI+L+F+NS3 Frame using the restriction enzymes BspEI and Sall and subcloned into the plasmid pEF-DHFR+CTI+CD80-M79scFv (V<sub>L</sub>/V<sub>H</sub>) (see Examples 1.1 and 1.2) cleaved with the same enzymes and thereby replacing the M79 scFv fragment by that of the human antibody VD4.5VK8 (see Figure 1.3.8) Transfection into CHO-cells and cell-culture procedures were performed as described in Example 1.1.1. The 17-1A-antigen-binding activity was analysed by ELISA (Figures 8.3 and 8.4) and flowcytometry (Figure 9.1 and 9.2) described in detail in Examples 8 and 9; however, no binding to the 17-1A-antigen could be detected by either method.

#### **Example 4: CD80- MACHscFv antibody construct**

Another murine anti-17-1A-antibody (MACH) obtained by the method described by Göttlinger (1986) Int. J. Cancer:38, 47-53., was analysed with respect to the antigen binding activity of its scFv-fragment at the C-terminus of a bifunctional single-chain construct. The corresponding immunoglobulin variable regions V<sub>L</sub> and V<sub>H</sub> were

cloned by RT-PCR according to Orlandi, (1989) Proc. Natl. Acad. Sci. USA: 86, 3833-3837 from the total RNA prepared from the hybridoma cell line and subsequently expressed in mammalian cells as chimeric antibody of the human IgG1<sub>kappa</sub>-Isotype according to Orlandi (1989) Proc. Natl. Acad. Sci. U.S.A.: 86, 3833-3837. The recombinant antibody proved to bind to the 17-1A-antigen resembling its murine parent antibody as determined by 17-1A-ELISA using the culture supernatants of the transfected and the hybridoma cell line, respectively. Detection of bound antibody was performed with an anti-human-or an anti-murine immunoglobulin antibody, respectively. Development of the ELISA and measurement of OD-values was performed as described in Example 8. The results are shown in Figure 4.

The Vk and Vh domains were cloned into pComb3H5BHIS (according to Examples 3 and 5). The murine anti-17-1A-scFv-fragment was introduced into plasmid the pEF-DHFR+CTI+ CD80-VD4.5VK8 (see Example 3) using the restriction enzymes BspEI and NotI, thus replacing the 17-1A-specific VD4.5VK8scFv fragment (Figure 1.3.9). The obtained expression plasmid was then transfected into CHO cells as described in Example 1.1. The 17-1A binding activity on was analysed by ELISA (Figures 8.3 and 8.4) and flowcytometry (Figure 9.1 and 9.2) described in detail in Examples 8 and 9; however, no binding to the 17-1A antigen could be detected by either method.

#### **Example 5: Construction of the phagmid vector pComb3H5BHIS**

As a starting point for a phage display vector applicable for the in vitro selection of antibody fragments according to the method of the present invention the vector pComb3H, a derivative of pComb3 (Barbas, Proc. Natl. Acad. Sci. U.S.A. 88 (1991) 7978-7982) was used (for cloning sites see Figure 5.1), providing:

- the bla-gene enabling carbenicilline resistance selection for positive transformation and infection with recombinant phage particles
- a procaryotic leader sequences for protein excretion of functional antibody fragments into bacterial periplasma

- an inducible lac-promotor for high protein productivity
- the coat domain CT of the M13 phage gene III product necessary for anchoring antibody fragments on the surface of filamentous phage (phage display).

For the detection and isolation of proteins expressed in the periplasma of E.coli, especially small scFv fragments, a His tag is highly preferable. Therefore the first step was to subclone a DNA-sequence encoding six Histidine residues downstream of the gene III sequence.

The pComb3H vector was cleaved with NheI and a double stranded oligonucleotide with suitable ends was inserted by ligation. The double stranded oligomer encoding the six His residues was created through annealing of the two 5'-phosphorylated primers His6s and His6as (at 94°C, 10 min.; 65 °C, 30 min.; 52 °C 30 min. and 30 °C 10 min.).

His6s: 5'-CTAGCCATCACCATCACCATCACACA-3'

His6as: 5'-CTAGTGTGATGGTGATGGTGATGG-3'

The primer ends were designed in a way that after fusion with the vector the 3' NheI restriction site was destroyed whereas the 5' NheI cleavage site remained intact.

The insert was sequenced to confirm successful cloning and the new vector designated pComb3HHis.

For the purpose of creating scFv-fragments linked to the gene III product with the C-terminus of the light chain variable domain (VK), a totally new multiple cloning site (mcs) had to be subcloned.

The first part of the original mcs of pComb3HHis was excised by SacI-Xhol digestion. The resulting vector fragment was ligated with a double stranded (ds) DNA fragment created by annealing of two 5'-phosphorylated primers (5BFors;5BForas) giving rise to 5' SacI and 3'Xhol compatible overhangs and

destroying the original 5' SacI cleavage site. The annealing of the two primers was carried out at 94°C, 10 min.; 65 °C, 30 min.; 52 °C 30 min. and 30 °C 10 min.

Primer sequences:

5BFors:

5'-GCAGCTGGTCGACAAATCCGGAGGTGGTGGATCCGAGGTGCAGCTGC-3'

5BForas:

5'-

TCGAGCAGCTGCACCTCGGATCCACCACCTCCGGATTGTCGACCAGCTGCAG  
CT-3'

The insert was sequenced to confirm successful cloning and the new vector designated pComb3HForHis. The original heavy chain cloning stuffer was then excised with Xhol and Spel, and the resulting vector fragment was ligated with another ds DNA-fragment, again created by annealing of two 5' phosphorylated primers (5BBacks; 5BBackas) under the same conditions used for the annealing of 5BFors and 5BForas.

Primer sequences:

5BBacks:

5'-

TCGAGCCCGGTACCGTCTCCTCAGGTGGTGGTTCTGGCGGCCGGCT  
CCGGTGGTGGTGGTTCTGAGCTCGGGA-3'

5BBackas:

5'-

CTAGTCCCAGCTCAGAACCAACCACCGGAGCCGCCGCCAGAACAC  
CACCACTGAGGAGACGGTGACCGGGC-3'

The whole insert was again sequenced to confirm successful cloning and the new vector designated pComb3HmcsHis (Figure 5.2).

This vector provides all necessary cloning sites for the cloning of scFv antibody fragments, a prokaryotic leader sequence for the transport of the recombinant proteins into the periplasm of E.coli, a linkage of scFV-fragments to the CT-domain of the geneIII-product of filamentous phage and after removal of the CT-encoding sequence a linkage to a histidine tag.

The last and most important step was to introduce a protein reducing the antigen binding activity of position-sensitive antibody fragments and being neutral to insensitive scFv-fragments so that its C-terminus will be fused to the N-terminus of subsequently cloned scFv-antibody-fragments.

The M13 gene III domain N2 corresponding to the amino acids 87 to 217 of the geneIII-product of bacteriophage fd (Beck, Nucl. Acid. Res. 5 (1978), 4495-4503) was chosen as a suitable protein to be fused to the N-terminus of scFv-fragments; unlike the complete geneIII-product, the N2-domain does not mediate phage infectivity.

The approximately 400bp N2-fragment was amplified by PCR (polymerase chain reaction) from VCSM13-phage (available from Stratagene) infected E.coli XL1blue (94°C, 4 min.; (94°C, 0,5 min.; 52°C, 1 min.; 72°C, 0,5 min.) x 40 cycles; 72°C, 10 min.; 30°C, 1 sec.) using the primers 5' N2 Sall and 3'N2 BspEI.

**Primer sequences:**

5' N2 Sall : 5'-GGTGTGACACTAACCTCCTGAGTACGG-3'

3'N2 BspEI : 5'-GCCTCCGGAAGCATTGACAGGAGGTTGAGG-3'

This fragment was then subcloned into the pComb3HmcsHis vector using the restriction sites, Sall and BspEI.

Correct subcloning was confirmed by DNA-sequencing. The resulting vector was designated pComb3H5BHs.

The sequence of its multiple cloning site is shown in Figure 5.2.

Figure 5.3 shows a plasmid map of pComb3H5BHIS with a cloned scFv-antibody-fragment.

Unless otherwise stated, the procedures used followed that described in Sambrook, Molecular Cloning, 'A Laboratory Manual', 2nd Edition, Cold Spring Harbour Laboratory Press, Cold Spring Harbour, NY (1989).

**Example 6: Construction of the combinatorial antibody library and phage display**

For immunization 25 µg soluble 17-1A-antigen in 100µl PBS were mixed with 100 µl incomplete Freuds Adjuvance (IFA) and injected subcutaneously into one mouse. After two and five weeks injection was repeated with the same amount of antigen mixed with the same volume (100 µl) of IFA, respectively.

Four weeks after the first injection, successful immunization was analysed by the 17-1A ELISA (see Example 8) using mouse-serum diluted 1:5, 1:50, and 1:500 followed by a peroxidase conjugated anti-mouse Ig-antibody. A strong signal was obtained in all concentrations compared to negative and cross-reactivity controls.

Three days after the third injection the murine spleen cells were harvested for the preparation of total RNA according to Chomczynski, Analytical biochemistry 162 (1987) 156-159.

A library of murine immunoglobuline (Ig) light chain (kappa) variable region (VK) and Ig heavy chain variable region ( $V_H$ ) DNA-fragments was constructed by RT-PCR on murine spleen RNA using VK- and  $V_H$  specific primer. cDNA was synthesized according to standard protocols (Sambrook, Cold Spring Harbour Laboratory Press 1989, second edition).

The primer sets (Table 1) were chosen to give rise to a 5'-Xhol and a 3'-BstEII recognition site for the heavy chain V-fragments and to a 5'-SacI and a 3'-SpeI recognition site for VK.

For the PCR-amplification of the  $V_H$  DNA-fragments eight different 5'- $V_H$ -family specific primers were each combined with one 3'- $V_H$  primer; for the PCR-amplification of the VK-chain fragments seven different 5'-VK-family specific primers

were each combined with one 3'-VK primer. Primer sets for the amplification of the V<sub>H</sub>- and VK-DNA-fragments (5' to 3') are shown in Table 1.

The following PCR program was used for amplification: denaturation at 94 °C for 20 sec.; primer annealing at 52 °C for 50 sec. and primer extension at 72 °C for 60 sec. and 40 cycles, followed by a 10 min. final extension at 72 °C.

450 ng of the kappa light chain fragments (Sacl-Spel digested) were ligated with 1400 ng of the phagmid pComb3H5BHis (Sacl-Spel digested; large fragment). The resulting combinatorial antibody library was then transformed into 300 µl of electrocompetent Escherichia coli XL1 Blue cells by electroporation (2.5 kV, 0.2 cm gap cuvette, 25 µ FD, 200 Ohm, Biorad gene-pulser) resulting in a library size of 6 x 10<sup>8</sup> independent clones. After one hour of phenotype expression, positive transformants were selected for carbenicilline resistance encoded by the pComb3H5BHis vector in 100 ml of liquid super broth (SB)-culture over night.

Cells were then harvested by centrifugation and plasmid preparation was carried out using a commercially available plasmid preparation kit (Qiagen).

2800 ng of this plasmid-DNA containing the VK-library (Xhol-BstEII digested; large fragment) were ligated with 900 ng of the heavy chain V-fragments (Xhol-BstEII digested) and again transformed into two 300 µl aliquots of electrocompetent E.coli XL1 Blue cells by electroporation (2.5 kV, 0.2 cm gap cuvette, 25 µ FD, 200 Ohm) resulting in a total V<sub>H</sub>-V<sub>K</sub> scFv (single chain variable fragment) library size of 4 x 10<sup>8</sup> independent clones.

After one hour of phenotype expression, positive transformation was selected by carbenicilline resistance.

After this adaptation, these clones were infected with an infectious dose of 1 x 10<sup>12</sup> particles of the helper phage VCSM13 resulting in the production and secretion of filamentous phages, each of them containing single stranded pComb3H5BHis-DNA encoding a murine scFv-fragment and displaying the corresponding scFv-protein fused to the N2 domain on the phage surface as a translational fusion to phage coat protein III (phage display, see Figure 6.2).

This phage library carrying the cloned scFv-repertoire was harvested from the culture supernatant by PEG8000/NaCl precipitation and centrifugation, re-dissolved in TBS/1%BSA and incubated with recombinant soluble 17-1A immobilized on 96 well ELISA plates. Soluble 17-1A was prepared as described (Mack, Proc. Natl. Acad. Sci. U.S.A. 92 (1995) 7021-7025. Phage particles expressing N2-fused scFv-fragments that did not specifically bind to the target antigen were eliminated by up to ten washing steps with TBS/Tween. Binding entities were eluted by using HCl-Glycine pH 2.2 and after neutralization with 2 M Tris pH 12, the eluat was used for infection of a new uninfected E.coli XL1 Blue culture. Cells successfully transduced with a pComb phagmid copy, encoding a murine scFv-fragment, were again selected for carbenicilline resistance and subsequently infected with VCMS13 helper phage to start the second round of antibody display and in vitro selection.

After five rounds of phage-production and subsequent selection for antigen-binding scFv-displaying phages, plasmid DNA from E.coli cultures was isolated corresponding to 3, 4 and 5 rounds of panning as well as to the unselected repertoire prior to the first round of panning.

For the production of soluble scFv-antibody-fragments that carry the N2-domain at their N-terminus, the DNA fragment encoding the CT-domain of the genelll-product was excised from the plasmids (Spel/Nhel), thus destroying the translational fusion anchoring the scFv-fragment to the phage surface. After religation this pool of plasmid DNA was transformed into 100 µl heat shock competent E.coli XL1 Blue cells and plated on Carbenicilline LB-Agar. Single colonies were grown in 10 ml LB-Carbenicilline-cultures/20 mM MgCl<sub>2</sub> and scFv-expression was induced after six hours by adding Isopropyl-β-D-thiogalactosid (IPTG) to a final concentration of 1 mM.

This in vitro selection procedure as well as the periplasmic expression of soluble antibody fragments was carried out according to Burton, Proc. Natl. Acad. Sci. USA 88 (1991), 10134-10137.

These cells were harvested after 20 hours by centrifugation and through four rounds of freezing at -70°C and thawing at 37°C the outer membrane of the bacteria was destroyed by temperature shock so that the soluble periplasmatic proteins including the N2-scFv fusion-proteins were released into solution. After elimination of intact

cells and cell-debris by centrifugation, the supernatant was tested by ELISA for 17-1A-binding N2-scFv-fusion-proteins.

Detection of N2-scFv-fragments bound to immobilized soluble 17-1A antigen was carried out using an anti-His-tag antibody (1µg/ml PBS) detected with horse radish peroxidase conjugated polyclonal anti mouse antibody (1µg/ml PBS). The signal was developed by adding ABTS substrate solution, as described in Example 8, and detected at a wavelength of 405 nm.

In contrast to clones prior to antigen selection many clones obtained after 3, 4 and 5 rounds of panning showed 17-1A-binding activity as shown in Figure 6.2.

The DNA-sequence of the V<sub>H</sub>- and V<sub>K</sub>-regions of some positive clones (3-1; 3-5; 3-8; 4-1; 4-4; 4-7; 5-3; 5-10 and 5-13) was determined but none of the clones turned out to have identical V<sub>H</sub> and VK DNA-sequence combinations (Figures 6.3-6.10 and 7). Unless otherwise stated, the procedures used followed that described in Sambrook, Molecular Cloning, 'A Laboratory Manual', 2nd Edition, Cold Spring Harbour Laboratory Press, Cold Spring Harbour, NY (1989).

**Example 7: Cloning of bifunctional CD80-anti-17-1A single-chain constructs by using the scFv-antibody-fragments generated by the method of the present invention**

The following nine 17-1A-specific scFv constructs obtained by the procedure described in Example 6

17-1A 3-1	in p-Comb3H-5B-His
17-1A 3-5	in p-Comb3H-5B-His
17-1A 3-8	in p-Comb3H-5B-His
17-1A 4-1	in p-Comb3H-5B-His
17-1A 4-4	in p-Comb3H-5B-His
17-1A 4-7	in p-Comb3H-5B-His
17-1A 5-3	in p-Comb3H-5B-His
17-1A 5-10	in p-Comb3H-5B-His

17-1A 5-13 in p-Comb3H-5B-His

were subcloned into the vector pEF-DHFR for stable expression in CHO-cells. In this step the N2-domain was replaced by the two extracellular domains of human CD80 (= B7-1).

For this purpose the vector pEF-DHFR + CTI + CD80 + scFv VD4.5VK8 described in Example 3 was cleaved the same way as the fragments derived from pComb3H5BHIs clones 3-1 to 5-13 using the restriction enzymes BspEI and NotI according to standard procedures (Sambrook, Molecular Cloning; A Laboratory Manual, Second Edition, Cold Spring Harbour Laboratory Press, Cold Spring Harbour, NY (1989)).

Both, vector and fragments were isolated on a 1% agarose gel, the specific bands were eluted using a commercial gel elution kit (Qiagen). After ligation DNA was transformed into the E.coli strain XL-1 blue by the standard heat shock method (Sambrook, Molecular Cloning; A Laboratory Manual, Second Edition, Cold Spring Harbour Laboratory Press, Cold Spring Harbour, NY (1989)).

Positive clones were detected by PCR-based colony screening with the following primers:

5' B7-1 5'- GCA GAA TTC ACC ATG GGC CAC ACA CGG AGG CAG-3'  
3' mu VK 5'-TGG TGC ACT AGT CGT ACG TTT GAT CTC AAG CTT GGT CCC-3'

One clone of each construct was grown to a 200 ml LB culture in the presence of 50 µg/ml ampicillin. Plasmid-DNA was purified with the commercially available Mega Prep kit (Qiagen) and linearized by the restriction enzyme Nde I. Finally these linearized plasmid-DNAs were transfected into dihydrofolate-reductase (DHFR) deficient CHO cells by electroporation at 260 V and 960 µFD as described (Mack, Proc. Natl. Acad. Sci. U.S.A. 92 (1995), 7021-7025).

Primary selection was carried out in nucleoside-free alpha MEM culture medium supplemented with 10% dialysed FCS as described (Kaufmann, Methods Enzymol. 185 (1990), 537-566).

The expression of these constructs was increased by gene amplification induced by the addition of the DHFR-inhibitor methotrexate (MTX) to a final concentration of 20nM as described (Kaufmann, Methods Enzymol. 185 (1990), 537-566).

**Example 8: ELISA-analysis of bifunctional CD80-anti-17-1A-scFv-constructs produced by the method of the present invention**

The culture supernatants of these transfected cell-lines derived from primary selection and first amplification step were tested by ELISA. Therefore recombinant soluble 17-1A (Mack, Proc. Natl. Acad. Sci. U.S.A. 92 (1995), 7021-7025) was coated to 96 well U-bottom ELISA plates (Nunc maxisorb) (50µg/ml 50µl/well) in phosphate buffered saline (PBS). Coating was performed overnight at 4°C, blocking was performed with 3% bovine serum albumin (BSA) in PBS for one hour at room temperature. Antibody constructs as culture supernatants from primary selection (PS) (Figure 8.1 and 8.2) and the first amplification step (1. Amp.) (Figure 8.3 and 8.4), respectively, were added and incubated for one hour at room temperature at different dilutions made in PBS containing 1% BSA.

Bound bifunctional antibody constructs were detected by a CD80-specific monoclonal antibody (Immunotech., Cat. No. 1449) diluted 1:1000 in PBS 1%BSA. After three times of washing with PBS 0,05% Tween20, a polyclonal peroxidase-conjugated Goat Anti-Mouse IgG-antibody (Fc-specific) was added and incubated at room temperature for one hour. After four times of washing with PBS 0,05% Tween20, the ELISA was finally developed by adding the following substrate solution: 22 mg ABTS (2,2 Azino-bis (3-Ethylbenzthiazoline-6 Sulfonic Acid) Diammonium salt) was dissolved in 10 ml 0,1 M citrat buffer pH 5,1 containing 2,3 mg Sodium perborate tetrahydrate. For negative controls, the plates were incubated with PBS instead of bifunctional antibody constructs. The coloured precipitate was measured at 405 nm using an ELISA-reader.

As shown in Figures 8.1 and 8.2, all clones proved to bind to the 17-1A-antigen with varying binding intensities.

**Example 9: Flowcytometry analysis of bifunctional CD80-anti-17-1A-scFv-constructs produced by the method of the present invention**

The culture supernatants from the first gene amplification step each containing one of the nine 17-1A-specific bifunctional CD80-scFv-constructs (Example 7) were tested on 17-1A-transfected CHO-cells by flow cytometry. These transfected cell-lines were generated by subcloning of a DNA-fragment encoding the complete amino acid sequence of the 17-1A-antigen also known as GA733-2 (Szala, Proc. Natl. Acad. Sci. U.S.A. 87 (1990), 3542-3546), into the eukaryotic expression vector pEF-DHFR according to standard procedures (Sambrook, Molecular Cloning; A Laboratory Manual, Second Edition, Cold Spring Harbour Laboratory Press, Cold Spring Harbour, NY (1989)); linearization of the resulting plasmid with the restriction enzyme Nde I and subsequent stable transfection into DHFR-deficient CHO cells was performed as described in Example 7. The expression of transmembrane 17-1A was increased by stepwise gene amplification induced by subsequent addition of increasing concentrations of the DHFR-inhibitor Methotrexat (MTX) to a final concentration of 500nM, with the concentration steps in between being 20nM and 100nM (Kaufmann, Methods Enzymol. 185 (1990), 537-566).

These cells were tested for membrane expression of 17-1A by flow cytometry using the 17-1A-specific monoclonal antibody M79 (Göttlinger, Int. J. Cancer 38 (1986), 47-53) at a concentration of 10 µg/ml followed by a polyclonal Goat Anti Mouse IgG + IgM (H+L) antibody diluted 1:100 in PBS. As negative control untransfected CHO cells were used whereas the 17-1A-positive human gastric cancer cell-line Kato, obtained from ATCC served as positive control. Results are shown in Figure 9.2..

Binding of the bifunctional CD80-scFv-constructs produced by the method of the present invention on 17-1A-positive cells was analysed as follows:

For this purpose adherent untransfected and 17-1A-transfected CHO-cells were detached using PBS containing 0,05% Trypsine, respectively.  $5 \times 10^5$  cells were incubated for 30 minutes on ice in 50  $\mu$ l culture supernatant containing the corresponding bifunctional construct undiluted (Figure 9.1). Bound bifunctional CD80-scFv-constructs were detected by a monoclonal anti-CD80 antibody (Immunotech. Cat. No: 1449) diluted 1:20 in 50  $\mu$ l PBS. Incubation conditions were the same as above. Bound CD80-antibody was finally detected by a fluorescein conjugated polyclonal Goat Anti-Mouse IgG + IgM (H+L) antibody diluted 1:100 in PBS. Incubation was again carried out for 30 minutes on ice. For the fixation of fluorescein-labeled cells 1% paraformaldehyd in PBS was used.

As first negative control untransfected CHO-cells were used. The second negative control contained 17-1A-transfected cells that were incubated with PBS instead of bifunctional CD80-scFv-constructs. Staining with the monoclonal antibody M79 (Göttlinger, Int. J. Cancer 38 (1986), 47-53) was used as positive control.

Cells were analysed by flow cytometry on a FACS scan (Becton Dickenson). FACS staining and measuring of the fluorescence intensity were performed as described in Current Protocols in Immunology (Coligan, Kruisbeek, Margulies, Shevach and Strober, Wiley-Interscience, 1992)

As shown in Figure 9.1 all nine bifunctional CD80-scFv-constructs bound to the 17-1A-antigen on the cell surface thus confirming the ELISA- results of Example 8.

**Example 10: Construction and binding analysis of bifunctional CD54-,CD58- and CD86-anti-17-1A single-chain constructs containing scFv- antibody-fragments generated by the method of the invention**

In order to confirm that specific 17-1A antigen binding of scFv-antibody fragments obtained by the method of the invention does not depend on a particular further N-terminal domain within a bifunctional single chain construct, the extracellular part of CD80 forming the N-terminal region of the recombinant single chain proteins

described in Examples 7-9 was replaced by that of CD54, CD58 and CD86, respectively. The construction of the different bifunctional single-chain constructs is described below.

### CD54 single-chain constructs

The CD54 antigen known as ICAM-1 (Intercellular adhesion molecule-1) belongs to the Ig-superfamily. It is a heavily glycosilated protein which is expressed on many lymphoid cells, e.g. dendritic-cells. A more detailed description was published by Simmons D. et.al. Nature 331 (1987) 624-626. The cDNA template was obtained by reverse transcription of the total RNA prepared from TPA-stimulated HL-60-cells. To amplify the extracellular region of CD54, specific primers for the 5' and 3' end were used. These primers also introduced the restriction cleavage-sites EcoR1 and BspE1 (5' ICAM: CTC GAA TTC ACT ATG GCT CCC AGC AGC CCC CG and 3'ICAM: GAT TCC GGA CTC ATA CCG GGG GGA GAG CAC ).

The CD54 -PCR fragment was cloned into the vector Bluescript KS+CTI+M79scFv (VL/VH) (see Example 1) using the restriction cleavage sites EcoR1 and BspE1, thus resulting in the vector Bluescript KS+CTI+CD54+M79scFv(VL/VH). The CD54-M79scFv (VL/VH) fragment was isolated by cleavage of the vector Bluescript KS+CTI+CD54+M79scFv(VL/VH) with EcoRI and Sall and subsequently introduced into the eukaryontic expression vector pEFDHFR (see Example 1). The resulting plasmid pEFDHFR CD54-M79scFv (VL/VH) was then cleaved with the restriction enzymes NdeI and BspEI in order to subclone the corresponding DNA-fragment (approximately 2 KB) containing the truncated CD54-sequence into the vectors pEFDHFR + CTI + CD80 +scFv anti 17-1A 4-7, pEFDHFR + CTI + CD80 +scFv anti 17-1A 5-3 and pEHDFR + CTI + CD80 +scFv anti 17-1A 5-10 (see Example 7), respectively, thereby replacing CD80 by CD54. The final plasmids were linearized with the restriction enzyme NdeI and transfected into CHO-cells by electroporation (see Example 1). The transfected CHO-cells (pEF-DHFR-CTI-CD54- anti 17-1A 4-7, pEF-DHFR-CTI-CD54- anti 17-1A 5-3 and pEF-DHFR-CTI-CD54- anti 17-1A 5-10) were grown for selection in nucleoside free  $\alpha$ -MEN medium supplemented with 10% dialyzed FCS and 2mM L-glutamine. The expression of these constructs was

subsequently increased by gene amplification induced by the addition of the DHFR-inhibitor methotrexate (MTX) to a final concentration of 20nM as described (Kaufman, Methods Enzymol. 185 (1990), 537-566)

Binding of the CD54-single-chain constructs to the 17-1A-antigen was analyzed using recombinant 17-1A-antigen obtained by stable expression in CHO-cells as described (Mack et.al. Proc.Natl.Acad.Sci. 92 (1995)7021-7025); the corresponding ELISA was performed as described in Example 8 using cell-culture supernatants, except that specific detection was carried out with an anti-human CD54 antibody diluted 1:1000 (Immunotech Hamburg, Cat.no 0544). The colored precipitate was measured at 405 nm using an ELISA-reader. The results shown in Figure 12 clearly demonstrate that binding of each of the constructed anti 17-1A-CD54 scFv constructs to the 17-1A-antigen could be detected.

### **CD58 single-chain constructs**

CD58 also known as LFA-3 (Lymphocyte Function-Associated Antigen) is a protein belonging to the Ig-superfamily and is the counterreceptor of CD2. A more detailed description was published by Wallner B.P. et.al. J.Exp.Med 166 (1987) 923-932). The cDNA template was obtained by reverse transcription of the total RNA prepared from U937 cells. To amplify the extracellular region of CD58 and to introduce the restriction enzyme cleavage sites Xba1 and BspE1, specific 5'and 3'primers were used (5'LFA-3 AA TCT AGA ACC ATG GTT GCT GGG AGC GAC G and 3'LFA-3 AAG TCC GGA TCT GTG TCT TGA ATG ACC GCT GC). The further cloning and expression procedure was the same as described above for the CD54 constructs except that XbaI instead of EcoRI was used due to an internal EcoRI-site within the CD58-DNA-fragment and a dam-methylase deficient E.coli-strain was used in order to prevent blocking of the BspEI site at the 3'-end of the CD58-fragment due to an overlapping dam-site. The finally resulting transfected CHO cells (pEF-DHFR-CTI-CD58- anti 17-1A 4-7, pEF-DHFR-CTI-CD58- anti 17-1A 5-3 and pEF-DHFR-CTI-CD58- anti 17-1A 5-10) were grown for selection in nucleoside free  $\alpha$ -MEN medium supplemented with 10% dialyzed FCS and 2mM L-glutamine. The expression of these constructs was subsequently increased by gene amplification induced by the

addition of the DHFR-inhibitor methotrexate (MTX) to a final concentration of 20nM as described (Kaufman, Methods Enzymol. 185 (1990), 537-566).

Binding of the CD58-single-chain constructs to the 17-1A-antigen was analyzed as described above except that the specific detection was carried out with an anti human CD58 antibody diluted 1:1000 (Immunotech, Hamburg Cat.no.0861). The results shown in Figure 12 clearly demonstrate that binding of each of the constructed anti 17-1A-CD58 scFv constructs to the 17-1A-antigen could be detected.

### CD86 single-chain constructs

The CD86 costimulatory protein also known as B7-2 belongs to the Ig superfamily. It is a heavily glycosylated protein of 306 amino acids. A more detailed description was published by Freeman G.J.et.al. Science 262 (1993) 909-911. The cDNA template was obtained by reverse transcription of the total RNA prepared from the Burkitt-Lymphoma cell line Raji. To amplify the extracellular region of CD86 specific 5' and 3' primers (5'B7-2: 5'AAG TCT AGA AAA TGG ATC CCC AGT GCA CTA TG 3', 3'B7-2: 5'AAT TCC GGA TGG GGG AGG CTG AGG GTC CTC AAG C '3) were used. These primers also introduce Xba1 and BspE1 cleavage sites which were used to clone the CD86 PCR-fragment into the vector Bluescript KS-CTI-M79scFv (VL/VH) (see Example 1). The further cloning and expression procedure was the same as described above for the CD54-construct except that Xba1 instead of EcoRI was used due to an internal EcoRI-site within the CD86-DNA-fragment. The finally resulting transfected CHO cells (pEF-DHFR-CTI-CD86- anti 17-1A 4-7, pEF-DHFR-CTI-CD86- anti 17-1A 5-3 and pEF-DHFR-CTI-CD86- anti 17-1A 5-10) were grown for selection in nucleoside free α-MEN medium supplemented with 10% dialyzed FCS and 2mM L-glutamine. The expression of these constructs was subsequently increased by gene amplification induced by the addition of the DHFR-inhibitor methotrexate (MTX) to a final concentration of 20nM as described (Kaufman, Methods Enzymol. 185 (1990), 537-566).

Binding of the CD86-single-chain constructs to the 17-1A-antigen was analyzed as described above except that the specific detection was carried out with an anti-human CD86 antibody diluted 1:1000 (R&D Systems, Cat.No. MB141) The results shown in Figure 12 clearly demonstrate that binding of each of the constructed anti 17-1A-CD86 scFv constructs to the 17-1A-antigen could be detected.

Table 1: Primer sets for the amplification of the VH- and VK-DNA-fragments (5' to 3')

murine V heavy chain:

5' primer

MVH1	5'- (GC)AGGTGCAGCTCGAGGAGTCAGGACCT-3'
MVH2	5'-GAGGTCCAGCTCGAGCAGTCTGGACCT-3'
MVH3	5'-CAGGTCCAACTCGAGCAGCCTGGGGCT-3'
MVH4	5'-GAGGTTCAGCTCGAGCAGTCTGGGGCA-3'
MVH5	5'-GA(AG)GTGAAGCTCGAGGAGTCTGGAGGA-3'
MVH6	5'-GAGGTGAAGCTTCTCGAGTCTGGAGGT-3'
MVH7	5'-GAAGTGAAGCTCGAGGAGTCTGGGGGA-3'
MVH8	5'-GAGGTTCAGCTCGAGCAGTCTGGAGCT-3'

3' primer

MUVHBstEII	5'-TGAGGAGACGGTGACCGTGGTCCCTGGCCCCAG-3'
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murine V kappa chain:

5' primer

MUVK1	5'-CCAGTTCCGAGCTCGTTGTGACTCAGGAATCT-3'
MUVK2	5'-CCAGTTCCGAGCTCGTGTGACGCAGCCGCC-3'
MUVK3	5'-CCAGTTCCGAGCTCGTGTACCCAGTCTCCA-3'
MUVK4	5'-CCAGTTCCGAGCTCCAGATGACCCAGTCTCCA-3'
MUVK5	5'-CCAGATGTGAGCTCGTGTGACCCAGACTCCA-3'
MUVK6	5'-CCAGATGTGAGCTCGTGTGACCCAGTCTCCA-3'
MUVK7	5'-CCAGTTCCGAGCTCGTGTGACACAGTCTCCA-3'

3' primer

MUVKHindIII/BsiWI	5'-TGGTGCACTAGTCGTACGTTGATCTCAAGCTTGGTCCC-3'
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## CLAIMS

1. A method of identifying a binding site domain having the capacity of binding to a predetermined epitope when positioned C-terminal of at least one further domain in a recombinant bi- or multivalent polypeptide comprising the steps of
  - (a) testing a panel of binding site domains displayed on the surface of a biological display system as part of a fusion protein for binding to a predetermined epitope, wherein said fusion protein comprises an additional domain positioned N-terminal of said binding site domain and an amino acid sequence that mediates anchoring of the fusion protein to the surface of said display system; and
  - (b) identifying a binding site domain that binds to said predetermined epitope.
2. The method of claim 1, wherein said binding site domain and said additional domain are linked by a polypeptide linker disposed between said binding site and said additional domain, wherein said polypeptide linker comprises plural, hydrophilic, peptide-bonded amino acids and connects the N-terminal end of said binding site domain and the C-terminal end of said additional domain.
3. The method of claim 1 or 2, wherein said binding site domain is a pair of  $V_H$ - $V_L$ ,  $V_H-V_H$  or  $V_L-V_L$  domains.
4. The method of any one of claims 1 to 3 wherein said display system is a filamentous phage produced by bacteria transfected therewith, a baculovirus expression system, a ribosome based expression system, a bacteriophage lambda display system or a bacterial surface expression system.
5. The method of claim 4 comprising, prior to step (a), the further step of
  - (a") transfecting bacteria with recombinant vectors encoding said fusion proteins.

6. The method of any one of claims 1 to 5 comprising, prior to step (a"), the further step of
    - (a') cloning a panel of nucleic acid molecules encoding said binding site domains into a vector.
  7. The method of claim 6, wherein said panel of nucleic acid molecules is derived from immune competent cells of a mammal, fish or bird.
  8. The method of any one of claims 1 to 7, wherein said additional domain comprises at least 9 amino acids.
  9. The method of claim 8, wherein said additional domain is or is derived from the N2-domain of the gene III product of filamentous phage.
  10. The method of any one of claims 1 to 9, wherein said sequence that mediates said anchoring is or is derived from the C-terminal CT-domain of the gene III product of filamentous phage.
  11. The method of any one of claims 1 to 8, wherein said bi- or multivalent polypeptide is a bi- or multifunctional polypeptide.
  12. The method of claim 9, wherein said at least one further domain comprises polypeptide selected from the group consisting of effector proteins having a conformation suitable for biological activity, amino acid sequences capable of sequestering an ion, and amino acid sequences capable of selective binding to a solid support.
  13. The method of claim 12 wherein said effector protein is an enzyme, toxin, receptor, binding site, biosynthetic antibody binding site, growth factor, cell-differentiation factor, lymphokine, cytokine, hormone, a remotely detectable moiety, or anti-metabolite.
  14. The method of claim 12 wherein said sequence capable of sequestering an ion is calmodulin, methallothionein, a fragment thereof, or an amino acid

sequence rich in at least one of glutamic acid, aspartic acid, lysine, and arginine.

15. The method of claim 12 wherein said polypeptide sequence capable of selective binding to a solid support is a positively or negatively charged amino acid sequence, a cysteine-containing amino acid sequence, streptavidin, or a fragment of Staphylococcus protein A.
16. The method of claim 13, wherein said receptor is a co-stimulatory surface molecule important for T-cell activation or comprises an epitope binding site or a hormone binding site.
17. The method of claim 16, wherein said co-stimulatory surface molecule is CD80 (B7-1), CD86 (B7-2), CD58 (LFA-3) or CD54 (ICAM-1).
18. The method of claim 17, wherein said epitope binding site is embedded in a pair of V<sub>H</sub>-V<sub>L</sub>, V<sub>H</sub>-V<sub>H</sub> or V<sub>L</sub>-V<sub>L</sub> domains.
19. The method of any one of claims 3 to 18, wherein said pair of domains are connected by a flexible linker, preferably by a polypeptide linker disposed between said domains, wherein said polypeptide linker comprises plural, hydrophilic, peptide-bonded amino acids of a length sufficient to span the distance between the C-terminal end of one of said domains and the N-terminal end of the other of said domains when said fusion protein assumes a conformation suitable for binding when disposed in aqueous solution.
20. The method of any one of claims 1 to 19, wherein the identification of said binding site domain comprises the steps of
  - (b') removing said amino acid sequence that mediates anchoring of the fusion protein to the surface of a phage from said fusion protein;
  - (b") periplasmatically expressing the nucleic acid molecules encoding the remainder of said fusion protein in bacteria; and
  - (b'") verifying whether said binding site domain binds to said predetermined epitope.

21. Kit comprising
  - (a) a panel of recombinant vectors encoding a panel of fusion proteins as defined in any one of claims 1 to 20; and/or
  - (b) a bacterial library transfected with a panel of vectors as defined in (a).
22. A binding site domain or fusion protein obtainable by the method of any one of claims 1 to 20, wherein said binding site domain comprises at least one complementarity determining region (CDR) of the scFv fragment shown in any one of figures 6.3 to 6.10 and 7.
23. A polypeptide or an antibody comprising at least one binding site domain or fusion protein of claim 22.
24. The polypeptide or antibody of claim 23 having the amino acid sequence as depicted in any one of figures 6.3 to 6.10 and 7.
25. Polynucleotides which upon expression encode the polypeptide or antibody of claim 23 or 24.
26. A cell transfected with a polynucleotide of claim 25.
27. A process for the preparation of a polypeptide or antibody of claim 23 or 24 comprising cultivating a cell of claim 26 under conditions suitable for the expression of the polypeptide and isolating the polypeptide from the cell culture medium.
28. A pharmaceutical composition containing a polypeptide or antibody of claim 23 or 24 and optionally a pharmaceutically acceptable carrier.
29. A diagnostic composition comprising the polypeptide or antibody of claim 23 or 24 and optionally suitable means for detection.

AMENDED SHEET

Figure 1.1

## Recombinant bifunctional single-chain protein

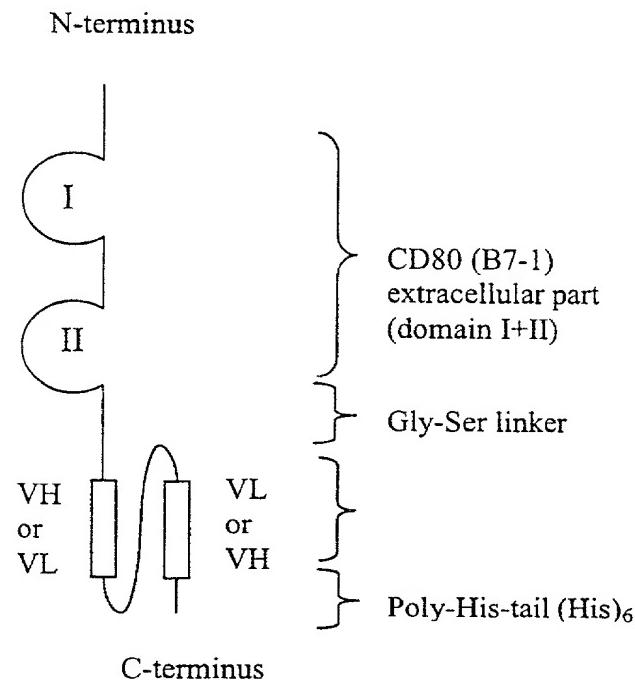


Figure 1.2 DNA-sequence designated CTI

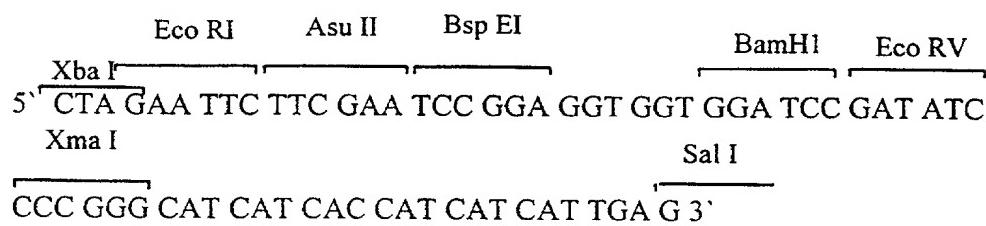


Figure 1.3 Design of various bifunctional CD80-scFv-constructs

Figure 1.3.1.

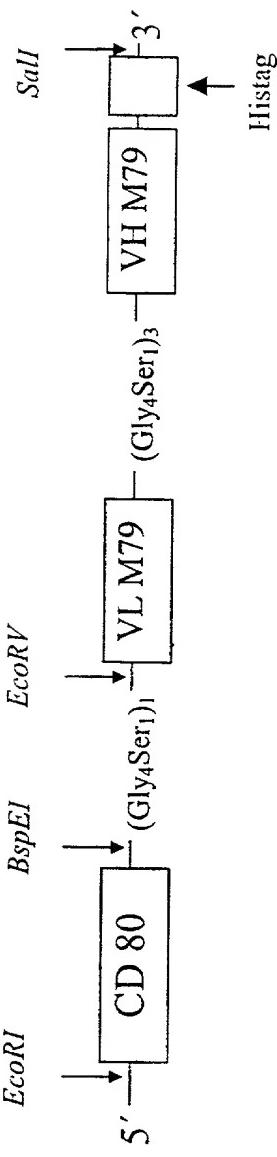


Figure 1.3.2.

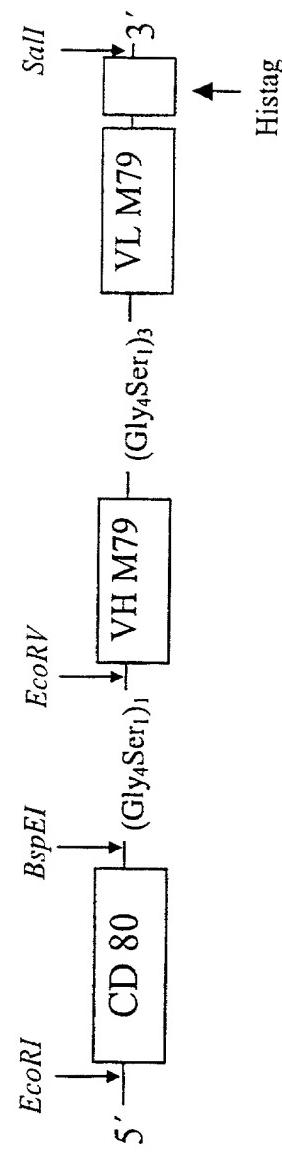


Figure 1.3.3.

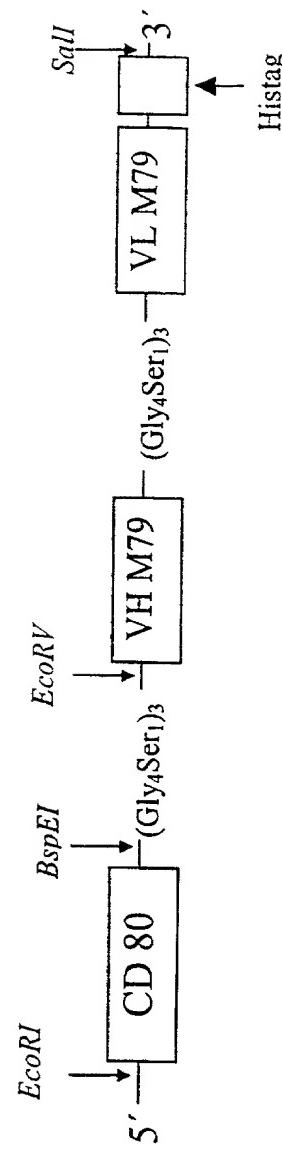


Figure 1.3.4.

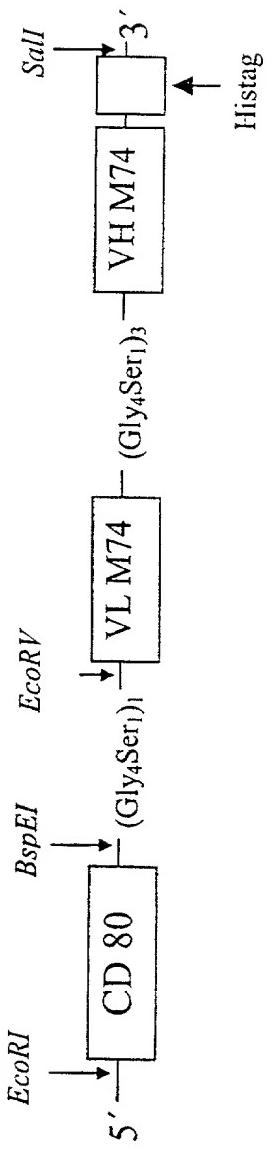


Figure 1.3.5.

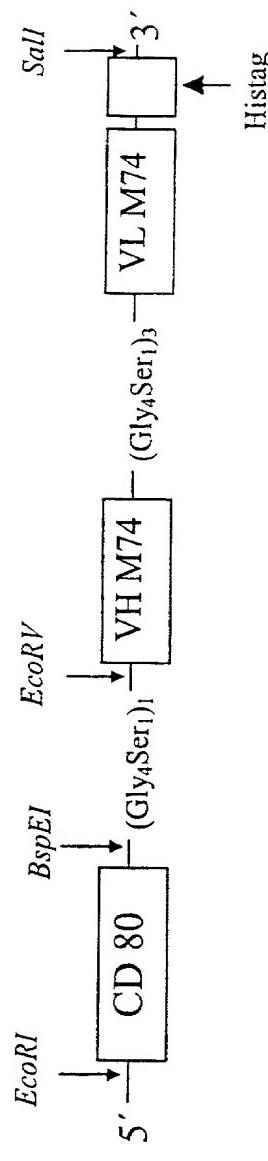


Figure 1.3.6.

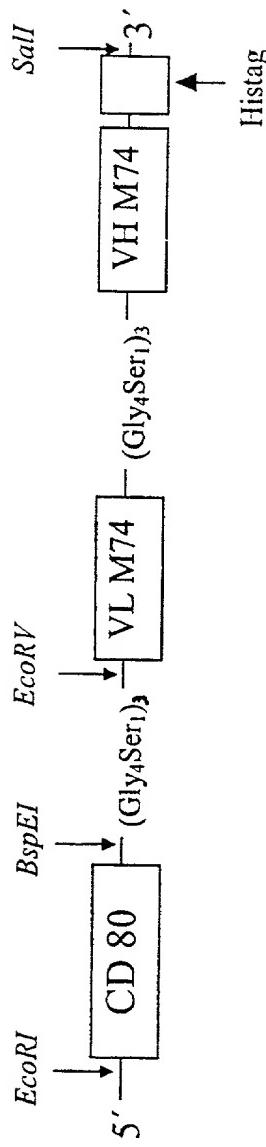


Figure 1.3.7

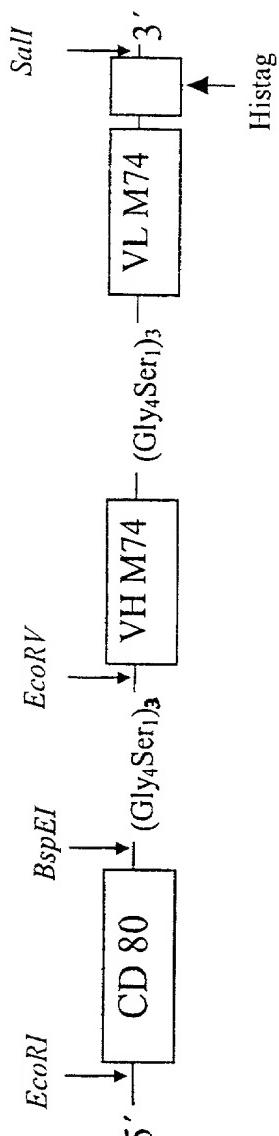


Figure 1.3.8.

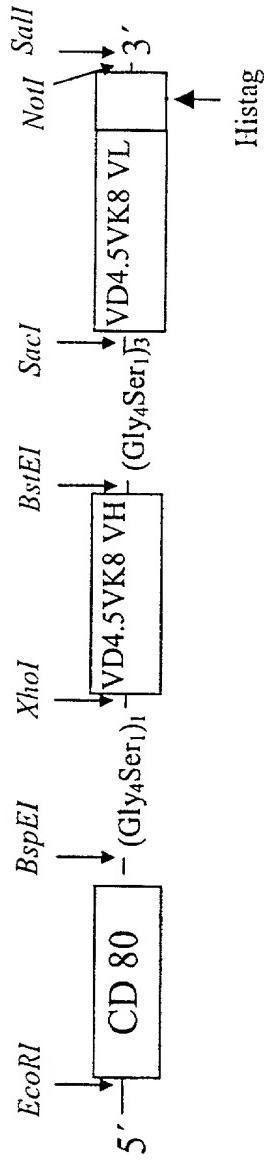


Figure 1.3.9.

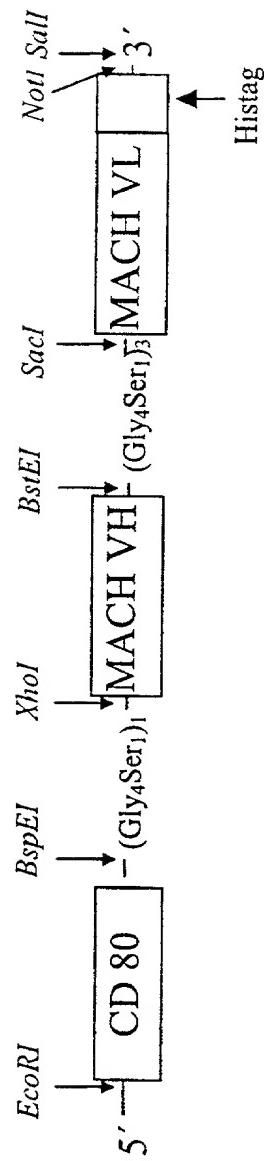


Figure 1.4

ELISA-analysis  
CD80-M79scFv (VL/VH) with short linker  
Detection: anti-His-tag

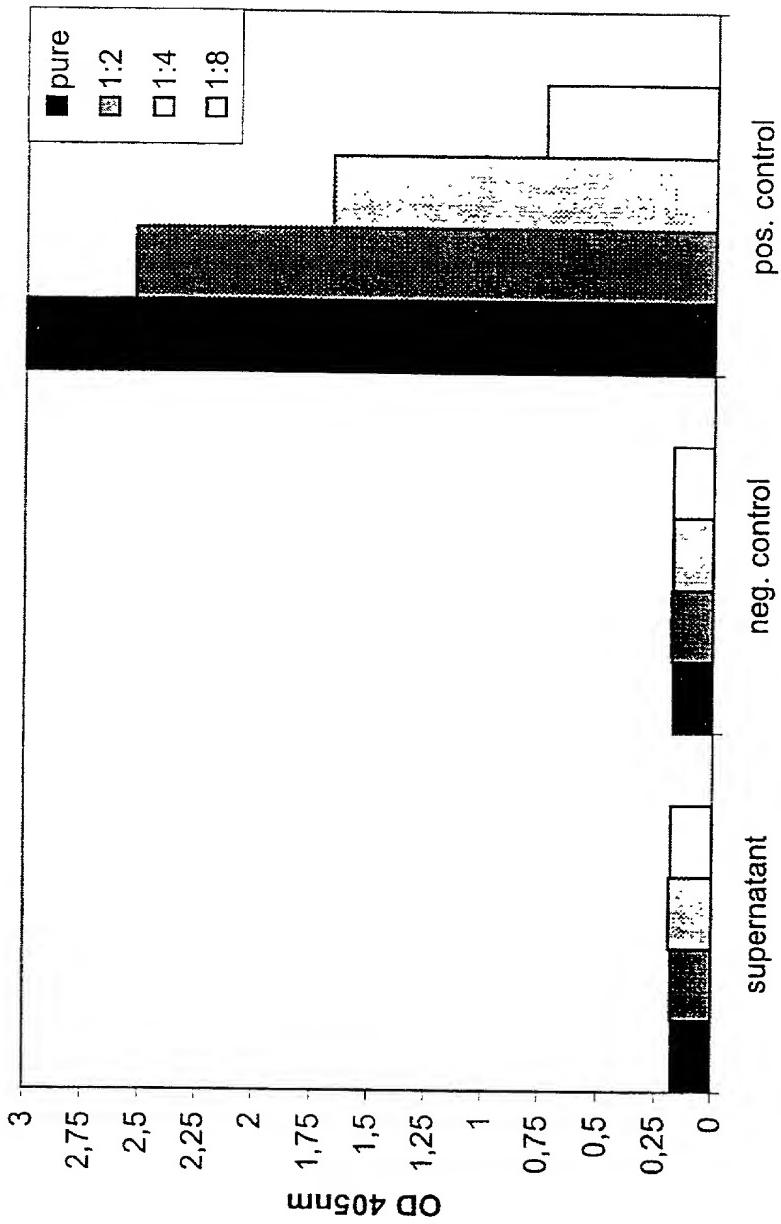


Figure 1.5

ELISA-analysis  
CD80-M79scFv (VL/VH) with short linker  
Detection: anti-CD80

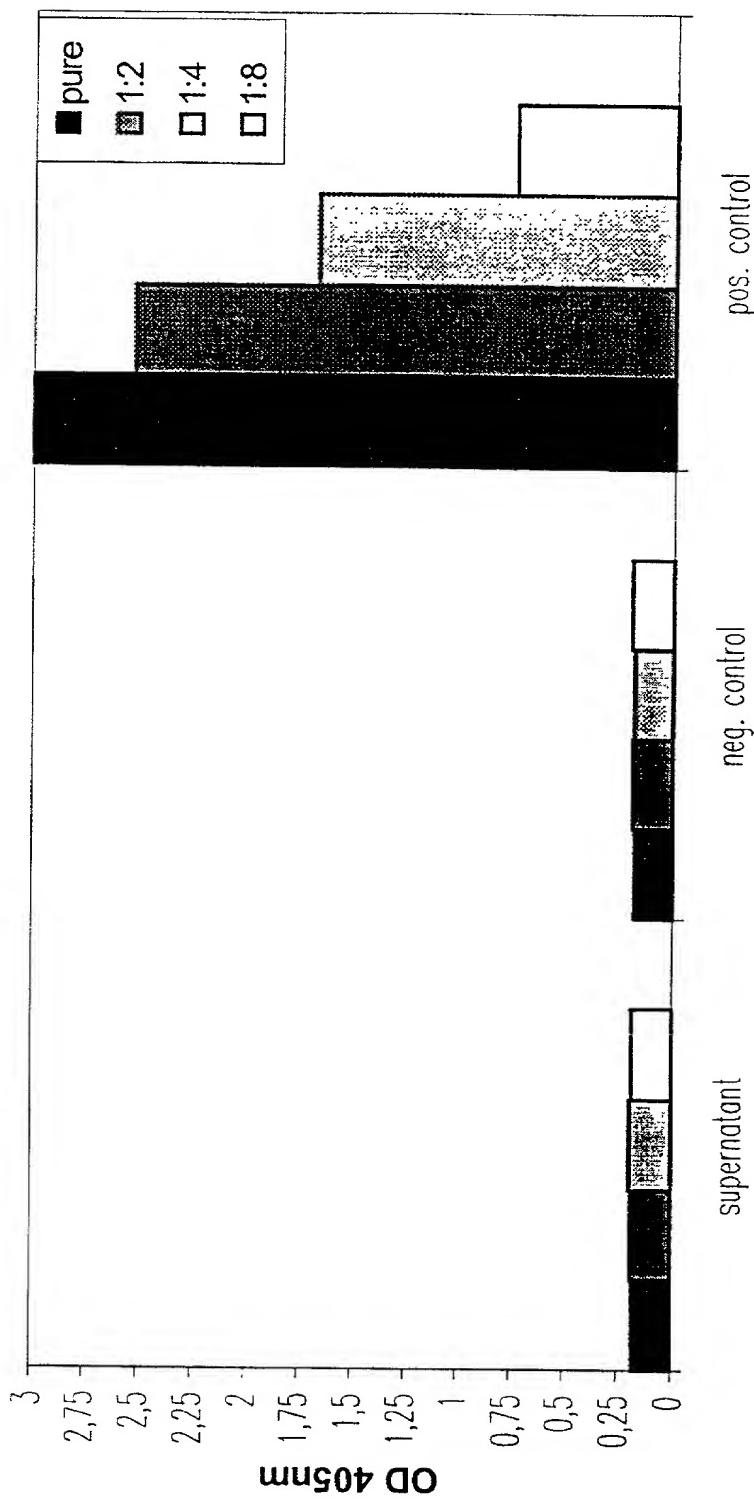


Figure 1.6

ELISA-analysis  
CD80-M79scFv (VL/VH) with short linker  
Detection: anti-His-tag or anti-CD80 (as indicated)

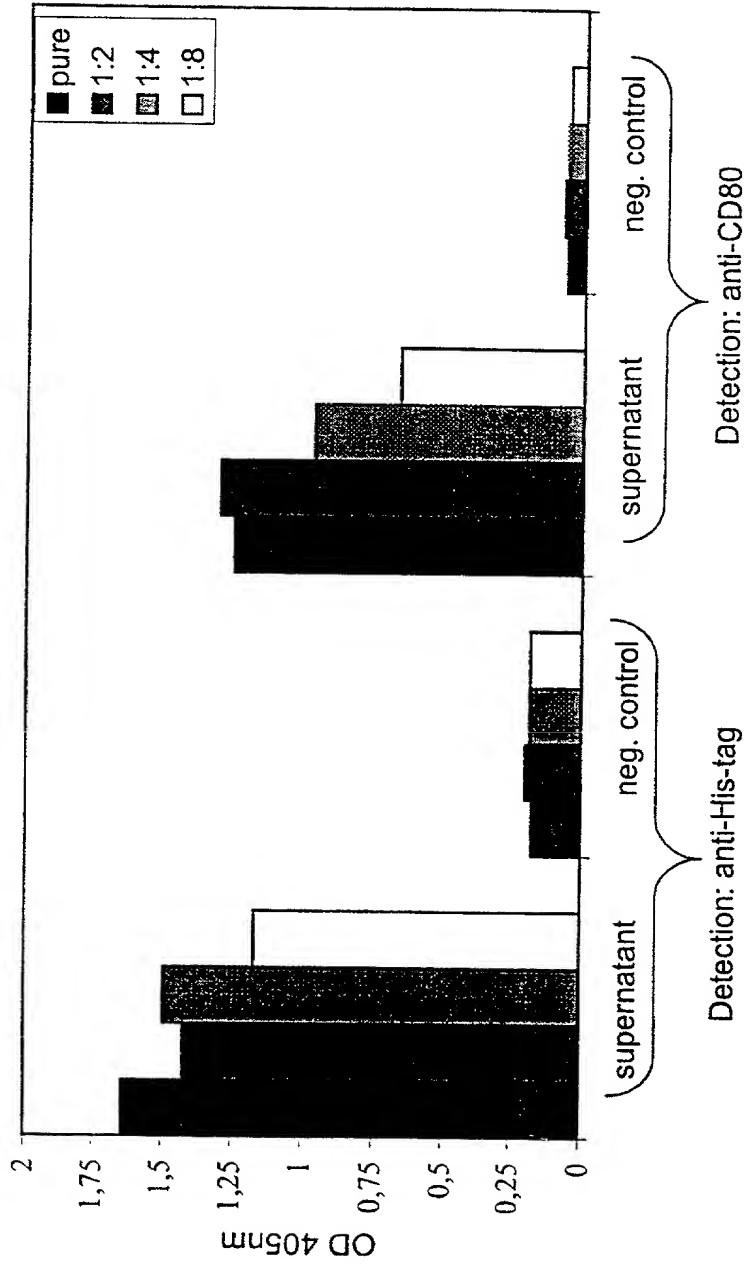


Figure 1.7

ELISA-analysis  
CD 80-M 79 scFv (VH/VL) with short linker  
Detection: anti-CD 80

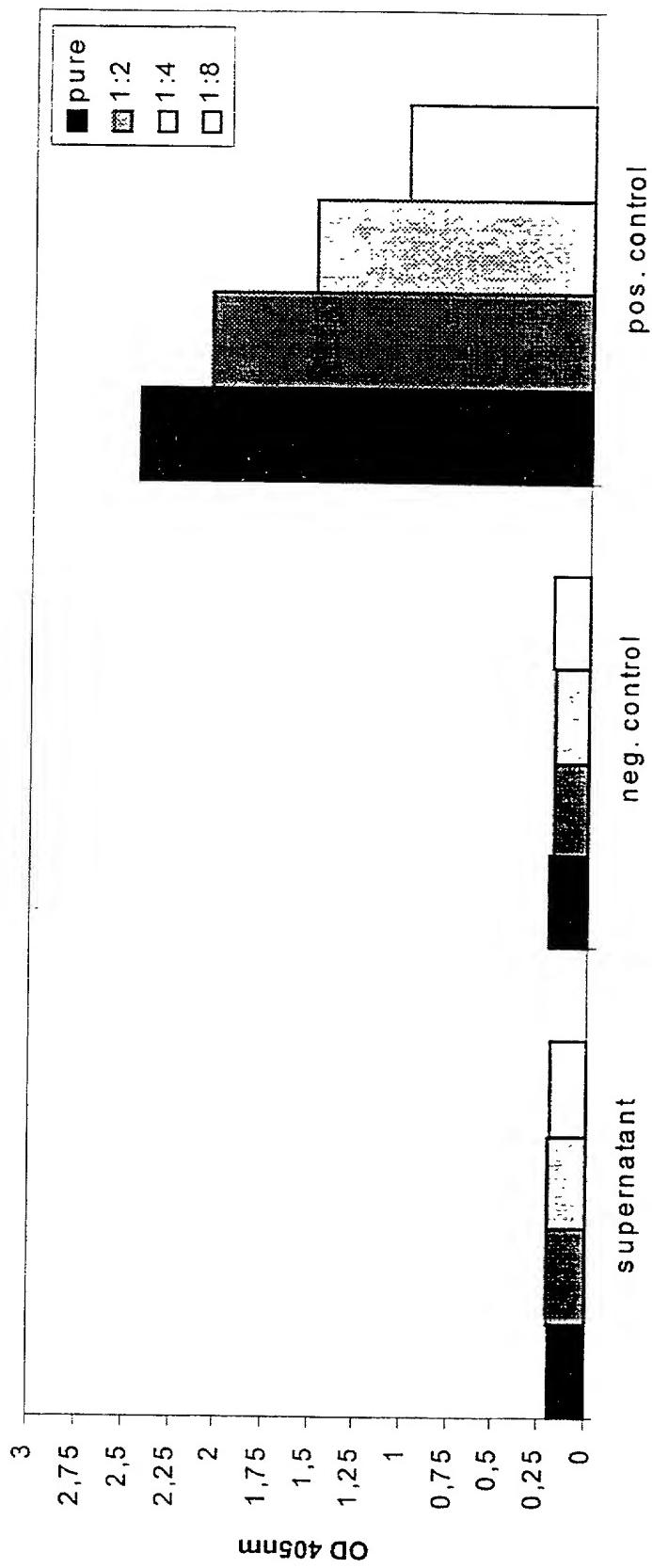


Figure 1.8 DNA-sequence of double-stranded oligonucleotide designated ACCGS15BAM

Figure 1.9

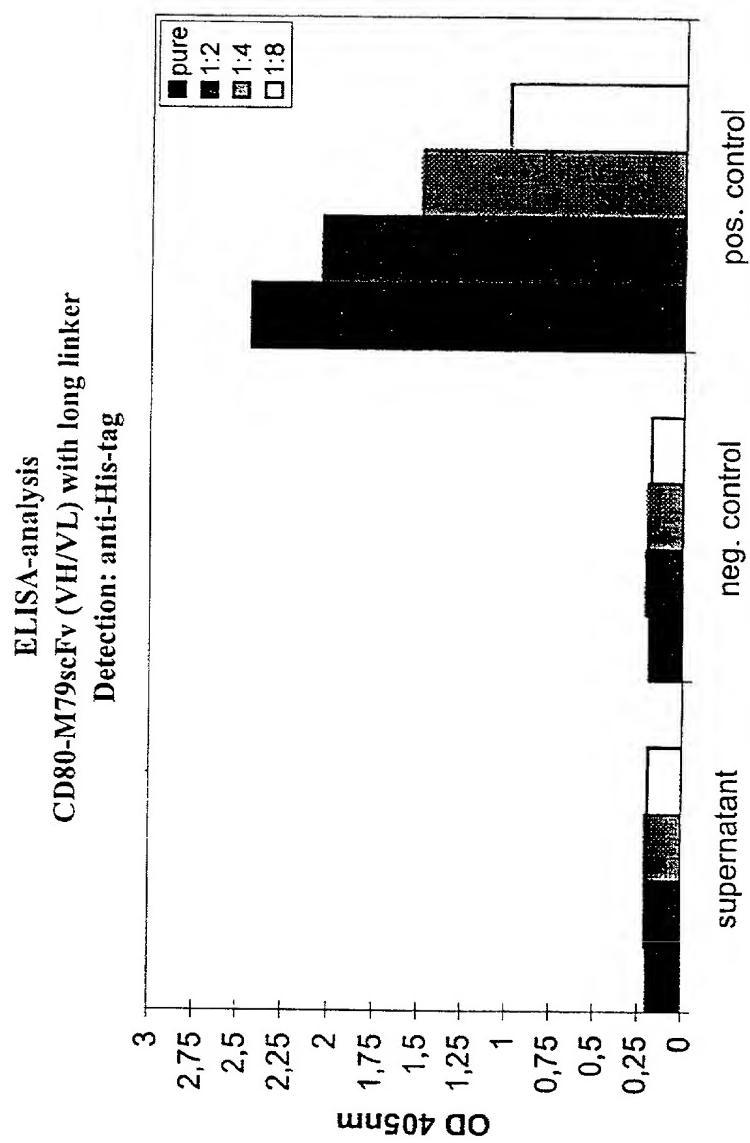


Figure 2.1

Elisa-analysis  
CD80-M74 scFv with different linker lengths and either  
VL/VH- or VH/VL-domain arrangement (as indicated)  
Detection: anti-His-tag

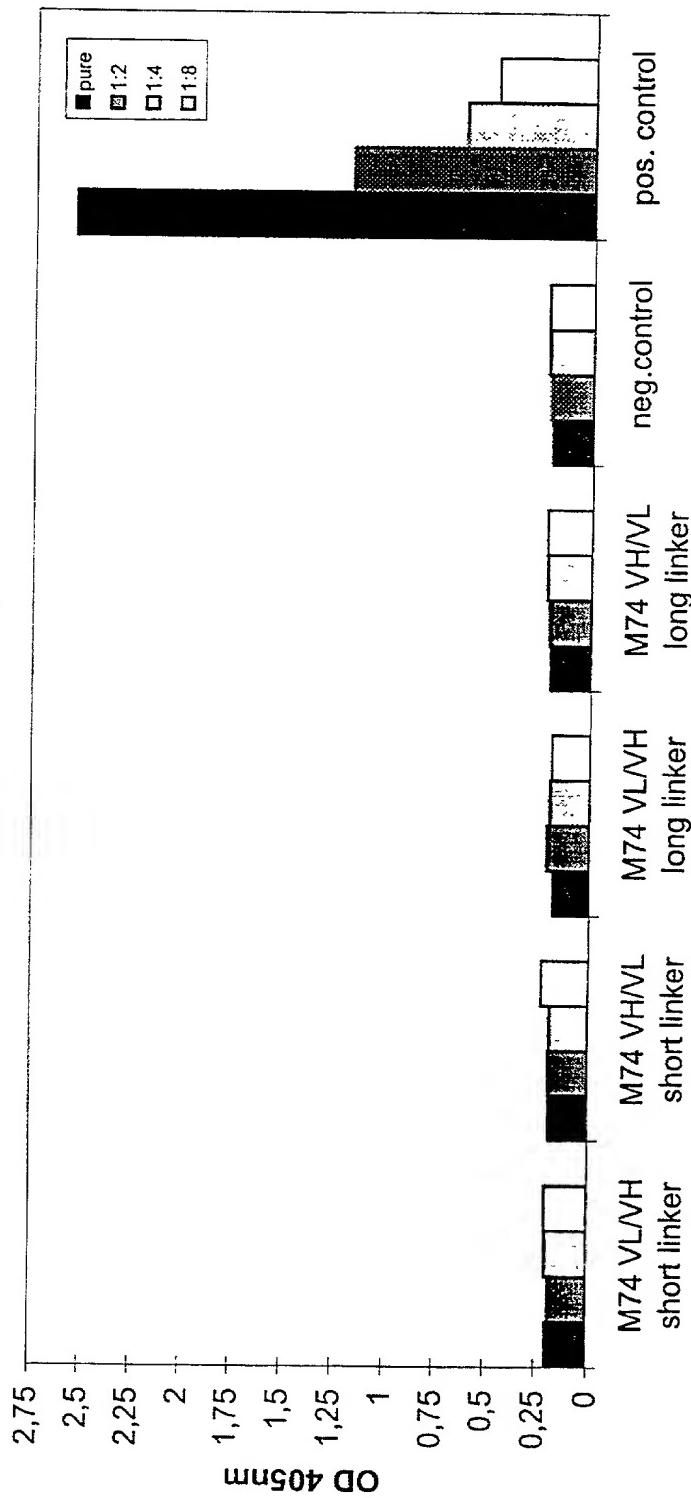


Figure 2.2

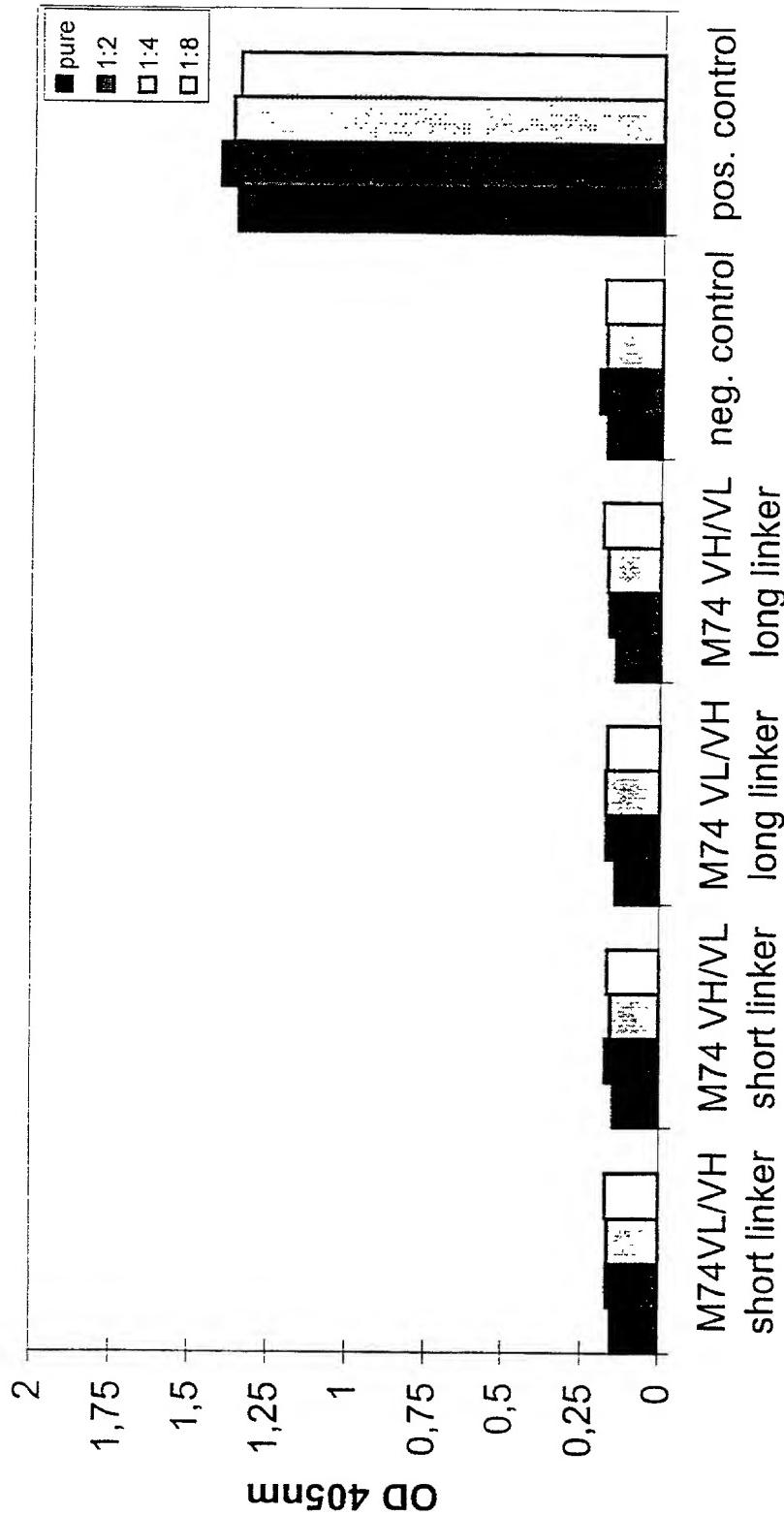
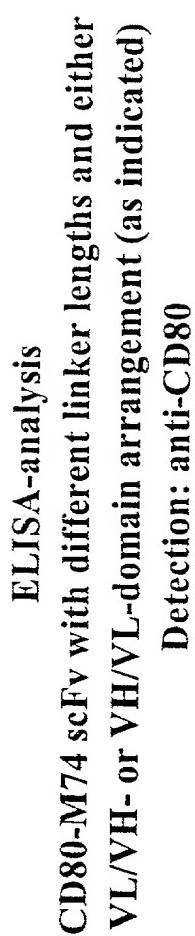


Figure 3.1

13/40

5' GAG GTG CAG CTG CTC GAG TCT GGG GGA GGC GTG GTC CAG CCT GGG AGG TCC CTG ----- E V Q L L E S G G V V Q P G R S L	9 18 27 36 45 54 ----- 63 72 81 90 99 108 AGA CTC TCC TGT GCA GCC TCT GGA TTC ACC TTC AGT AGC TAT GGC ATG CAC TGG ----- R L S C A A S G F T F S S Y G M H W	117 126 135 144 153 162 GTC CGC CAG GCT CCA GGC AAG GGG CTG GAG TGG GTG GCA GTT ATA TCA TAT GAT ----- V R Q A P G K G L E W V A V I S Y D	171 180 189 198 207 216 GGA AGT AAT AAA TAC TAT GCA GAC TCC GTG AAG GGC CGA TTC ACC ATC TCC AGA ----- G S N K Y Y A D S V K G R F T I S R	225 234 243 252 261 270 GAC AAT TCC AAG AAC ACG CTG TAT CTG CAA ATG AAC AGC CTG AGA GCT GAG GAC ----- D N S K N T L Y L Q M N S L R A E D	279 288 297 306 315 324 ACG GCT GTG TAT TAC TGT GCG AAA GAT ATG GGG TGG GGC AGT GGC TGG AGA CCC ----- T A V Y Y C A K D M G W G S G W R P	333 342 351 360 369 378 TAC TAC TAC TAC GGT ATG GAC GTC TGG GGC CAA GGG ACC ACG GTC ACC GTC TCC ----- Y Y Y Y G M D V W G Q G T T V T V S	TCA 3' --- S
--	--	--	--	--	--	--	--------------------

Figure 3.2

14/40

	9	18	27	36	45	54
5'	GAG CTC CAG ATG ACC CAG TCT CCA TCC TCC CTG TCT GCT TCT GTG GGA GAC AGA					
	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -
	E L Q M T Q S P S S L S A S V G D R					
	63	72	81	90	99	108
	GTC ACC ATC ACT TGT CGG ACA AGT CAG AGC ATT AGC AGC TAT TTA AAT TGG TAT					
	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -
	V T I T C R T S Q S I S S Y L N W Y					
	117	126	135	144	153	162
	CAG CAG AAA CCA GGA CAG CCT CCT AAG CTG CTC ATT TAC TGG GCA TCT ACC CGG					
	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -
	Q Q K P G Q P P K L L I Y W A S T R					
	171	180	189	198	207	216
	GAA TCC GGG GTC CCT GAC CGA TTC AGT GGC AGC GGG TCT GGG ACA GAT TTC ACT					
	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -
	E S G V P D R F S G S G S G T D F T					
	225	234	243	252	261	270
	CTC ACC ATC AGC AGT CTA CAA CCT GAA GAT TCT GCA ACT TAC TAC TGT CAG CAG					
	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -
	L T I S S L Q P E D S A T Y Y C Q Q					
	279	288	297	306	315	
	AGT TAC GAC ATC CCG TAC ACT TTT GGC CAG GGG ACC AAG CTG GAG ATC AAA 3'					
	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -
	S Y D I P Y T F G Q G T K L E I K					

Figure 3.3

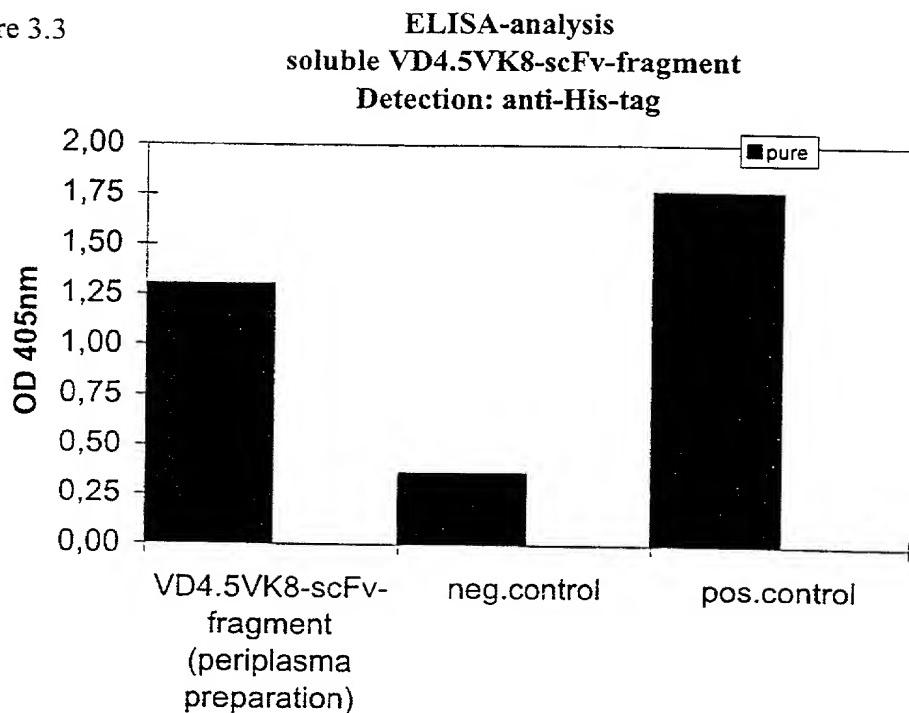


Figure 3.4 DNA-sequence designated L-F-NS3Frame

Figure 4

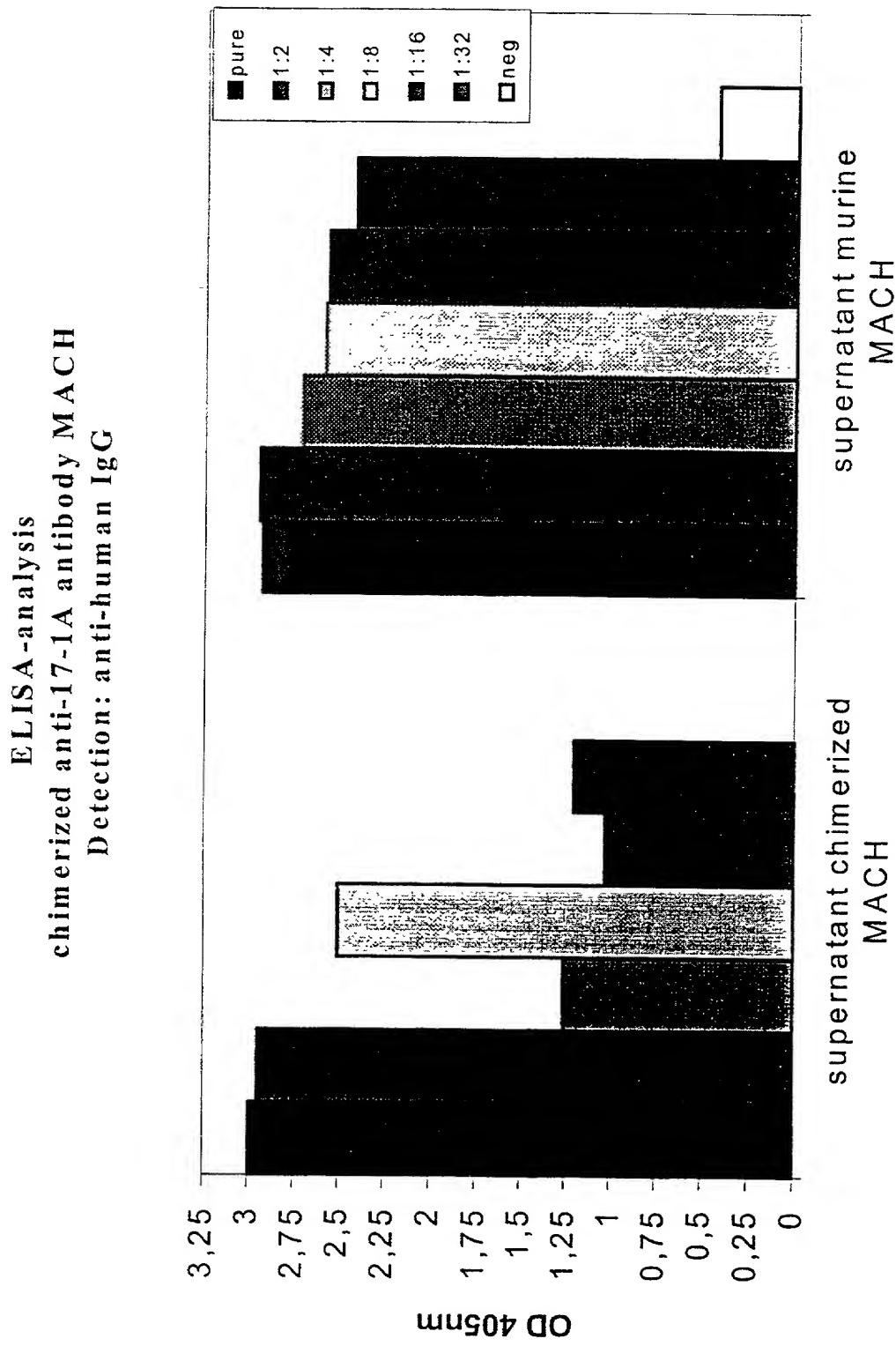


Figure 5.1

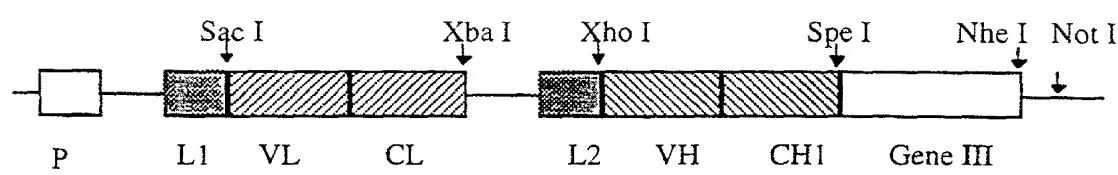


Figure 5.2

18 / 40

destroyed

SacI      9      Sall      18      27      36      45      54

5' GAG CTG CAG CTG GTC GAC ACT AAA CCT CCT GAG TAC GGT GAT ACA CCT ATT CCG  
----- T K P P E Y G D T P I P

63      72      81      90      99      108

GGC TAT ACT TAT ATC AAC CCT CTC GAC GGC ACT TAT CCG CCT GGT ACT GAG CAA  
----- G Y T Y I N P L D G T Y P P G T E Q

117      126      135      144      153      162

AAC CCC GCT AAT CCT AAT CCT TCT CTT GAG GAG TCT CAG CCT CTT AAT ACT TTC  
----- N P A N P S L E E S Q P L N T F

171      180      189      198      207      216

ATG TTT CAG AAT AAT AGG TTC CGA AAT AGG CAG GGG GCA TTA ACT GTT TAT ACG  
----- M F Q N N R F R N R Q G A L T V Y T

225      234      243      252      261      270

GGC ACT GTT ACT CAA GGC ACT GAC CCC GTT AAA ACT TAT TAC CAG TAC ACT CCT  
----- G T V T Q G T D P V K T Y Y Q Y T P

279      288      297      306      315      324

GTA TCA TCA AAA GCC ATG TAT GAC GCT TAC TGG AAC GGT AAA TTC AGA GAC TGC  
----- V S S K A M Y D A Y W N G K F R D C

333      342      351      360      369      378

GCT TTC CAT TCT GGC TTT AAT GAG GAT CCA TTC GTT TGT GAA TAT CAA GGC CAA  
----- A F H S G F N E D P F V C E Y Q G Q

387      396      405      BspEI      423      432

TCG TCT GAC CTG CCT CAA CCT CCT GTC AAT GCT TCC GGA GGT GGT GGA TCC GAG  
----- S S D L P Q P V N A S G G G G S

441      XhoI      450      BstEII      459      468      477      486

GTG CAG CTG CTC GAG CCC GGT CAC CGT CTC CTC AGG TGG TGG TGG TTC TGG CGG  
-----

495      504      SacI      SpeI

CGG CGG CTC CGG TGG TGG TTC TGA GCT CGG GAC TAG T 3'

Figure 5.3

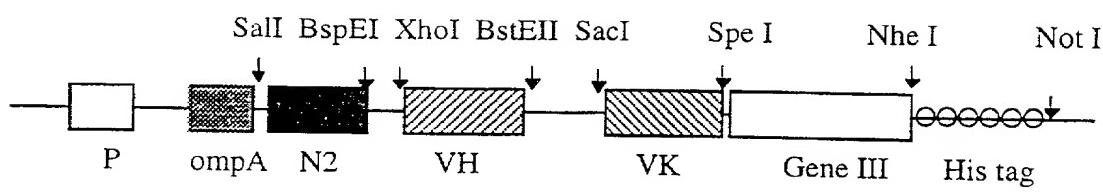


Figure 6.1

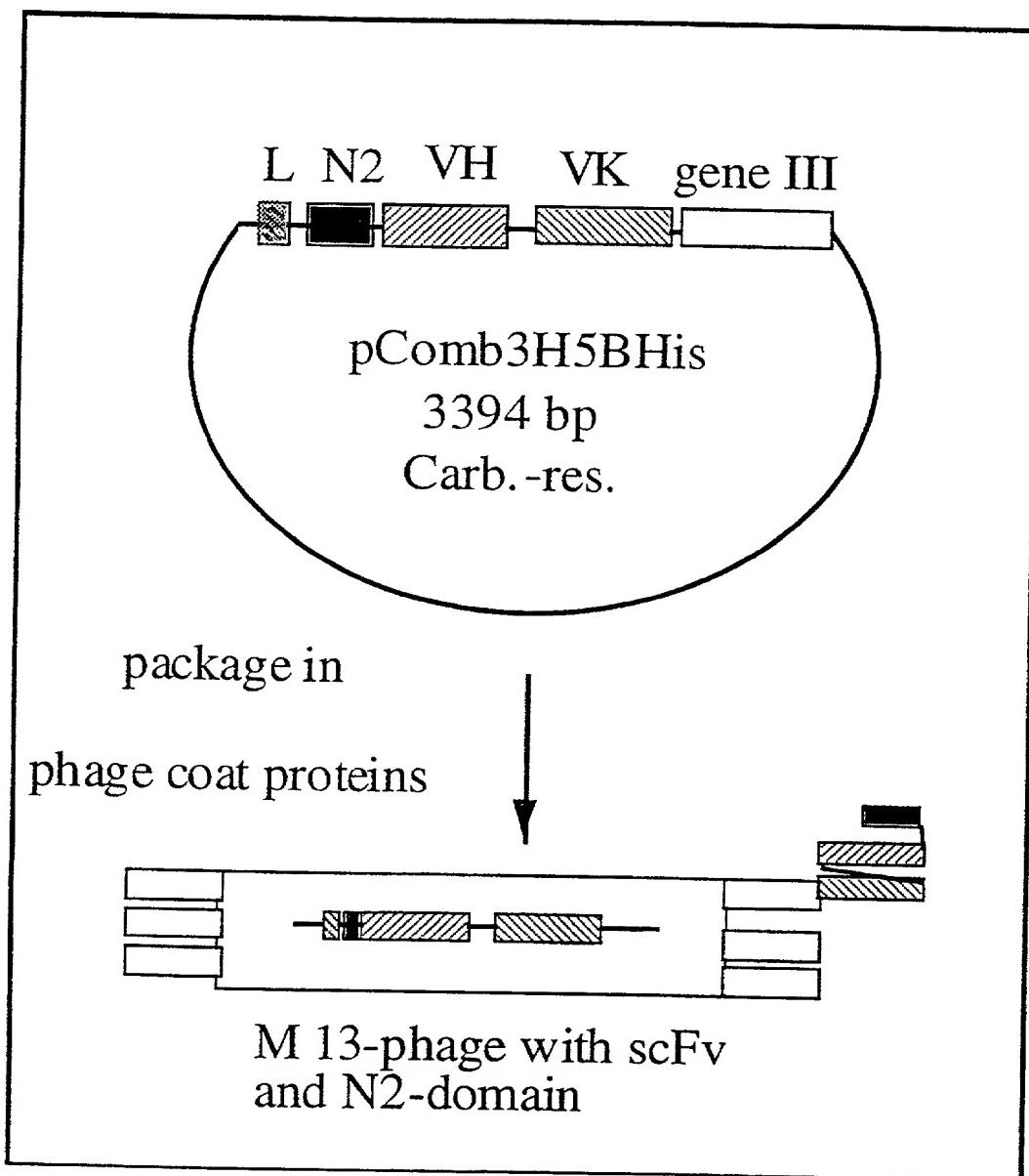


Figure 6.2

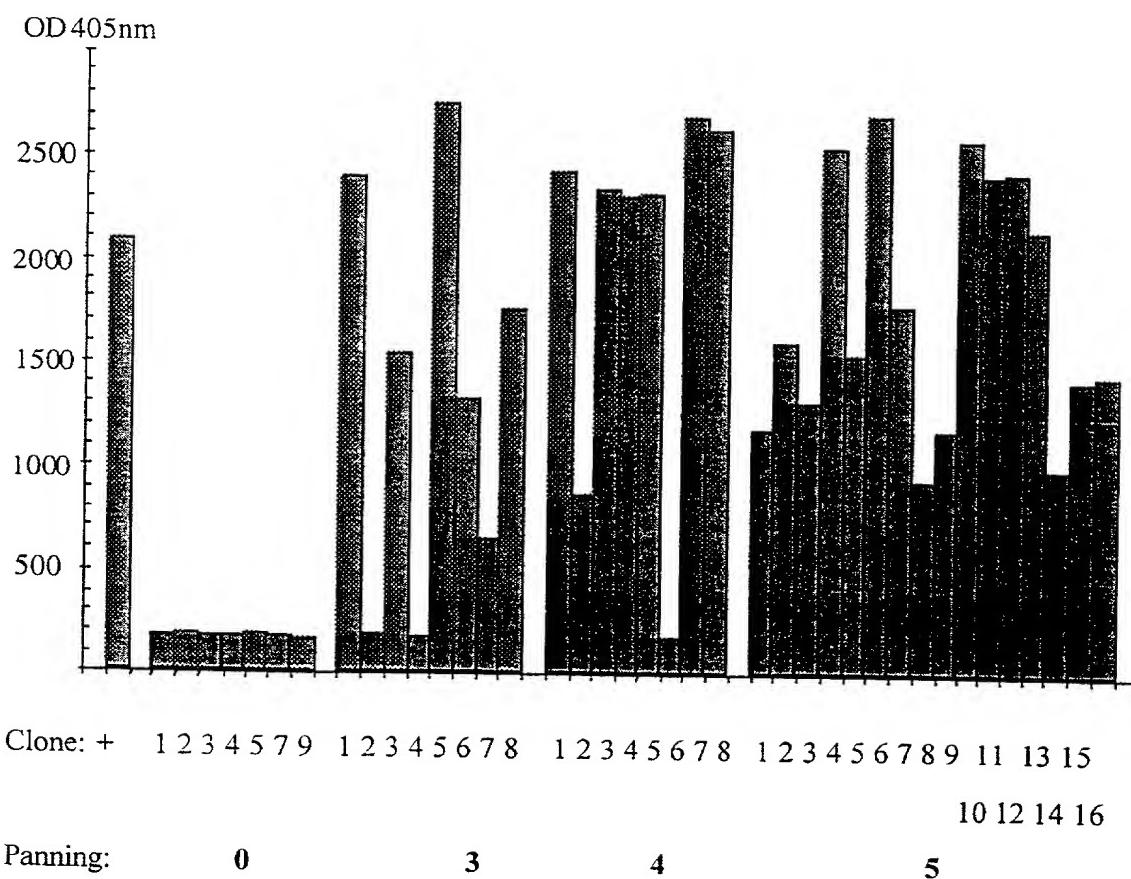


Figure 6.3

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Figure 6.4

23 / 40

9            18            27            36            45            54

5' GAG GTG CAG CTG CTC GAG CAG TCT GGA GCT GAG CTG GTA AGG CCT GGG ACT TCA  
-----  
E V Q L L E Q S G A E L V R P G T S  
63 72 81 90 99 108  
GTG AAG CTG TCC TGC AAG GCT TCT GGC TAC ACC TTC ACA AGC TAT GGT TTA AGC  
-----  
V K L S C K A S G Y T F T S Y G L S  
117 126 135 144 153 162  
TGG GTG AAG CAG AGA ACT GGA CAG GGC CTT GAG TGG ATT GGA GAG GTT TAT CCT  
-----  
W V K Q R T G Q G L E W I G E V Y P  
171 180 189 198 207 216  
AGA ATT GGT AAT GCT TAC TAC AAT GAG AAG TTC AAG GGC AAG GCC ACA CTG ACT  
-----  
R I G N A Y Y N E K F K G K A T L T  
225 234 243 252 261 270  
GCA GAC AAA TCC TCC AGC ACA GCG TCC ATG GAG CTC CGC AGC CTG ACA TCT GAG  
-----  
A D K S S T A S M E L R S L T S E  
279 288 297 306 315 324  
GAC TCT GCG GTC TAT TTC TGT GCA AGA CGG GGA TCC TAC GGT AGT AAC TAC GAC  
-----  
D S A V Y F C A R R G S Y G S N Y D  
333 342 351 360 369 378  
TGG TAC TTC GAT GTC TGG GGC CAA GGG ACC ACG GTC ACC GTC TCC TCA GGT GGT  
-----  
W Y F D V W G Q G T T V T V S S G G  
387 396 405 414 423 432  
GCT GGT TCT GGC GGC GGC TCC GGT GGT GGT TCT GAG CTC GTG ATG ACC  
-----  
G G S G G G S G G G S E L V M T  
441 450 459 468 477 486  
CAG ACT CCA CTC TCC CTG CCT GTC AGT CTT GGA GAT CAA GCC TCC ATC TCT TGC  
-----  
Q T P L S L P V S L G D Q A S I S C  
495 504 513 522 531 540  
AGA TCT AGT CAG AGC CTT GTA CAC AGT AAT GGA AAC ACC TAT TTA CAT TGG TAC  
-----  
R S S Q S L V H S N G N T Y L H W Y  
549 558 567 576 585 594  
CTG CAG AAG CCA GGC CAG TCT CCA AAG CTC CTG ATC TAC AAA GTT TCC AAC CGA  
-----  
L Q K P G Q S P K L L I Y K V S N R  
603 612 621 630 639 648  
TTT TCT GGG GTC CCA GAC AGG TTC AGT GGC AGT GGA TCA GGG ACA GAT TTC ACA  
-----  
F S G V P D R F S G S G T D F T  
657 666 675 684 693 702  
CTC AAG ATC AGC AGA GTG GAG GCT GAG GAT CTG GGA GTT TAT TTC TGC TCT CAA  
-----  
L K I S R V E A E D L G V Y F C S Q  
711 720 729 738 747  
AGT ACA CAT GTT CCG TAC ACG TTC GGA GGG GGG ACC AAG CTT GAG ATC AAA 3'  
-----  
S T H V P Y T F G G G T K L E I K

Figure 6.5

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Figure 6.6

25 / 40

	9	18	27	36	45	54													
5'	GAG	GTG	CAG	CTG	CTC	GAG	CAG	TCT	GGA	GCT	GAG	CTG	GTA	AGG	CCT	GGG	ACT	TCA	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	E	V	Q	L	L	E	Q	S	G	A	E	L	V	R	P	G	T	S	
	63					72		81				90			99			108	
	GTG	AAG	ATA	TCC	TGC	AAG	GCT	TCT	GGA	TAC	GCC	TTC	ACT	AAC	TAC	TGG	CTA	GGT	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	V	K	I	S	C	K	A	S	G	Y	A	F	T	N	Y	W	L	G	
	117			126			135				144			153			162		
	TGG	GTT	AAG	CAG	AGG	CCT	GGA	CAT	GGA	CTT	GAA	TGG	GTT	GGA	GAT	ATT	TTC	CCT	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	W	V	K	Q	R	P	G	H	G	L	E	W	V	G	D	I	F	P	
	171			180			189				198			207			216		
	GGA	AGT	GGT	AAT	GCT	CAC	TAC	AAT	GAG	AAG	TTC	AAG	GGC	AAA	GCC	ACA	CTG	ACT	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	G	S	G	N	A	H	Y	N	E	K	F	K	G	K	A	T	L	T	
	225			234			243			243		252			261			270	
	GCA	GAC	AAG	TCC	TCG	TAC	ACA	GCC	TAT	ATG	CAG	CTC	AGT	AGC	CTG	ACA	TCT	GAG	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	A	D	K	S	S	Y	T	A	Y	M	Q	L	S	S	L	T	S	E	
	279			288			297			297		306			315			324	
	GAC	TCT	GCT	GTC	TAT	TTC	TGT	GCA	AGA	TTG	CGG	AAC	TGG	GAC	GAG	GCT	ATG	GAC	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	D	S	A	V	Y	F	C	A	R	L	R	N	W	D	E	A	M	D	
	333			342			351			351		360			369			378	
	TAC	TGG	GGC	CAA	GGG	ACC	ACG	GTC	ACC	GTC	TCC	TCA	GGT	GGT	GGT	GGT	TCT	GGC	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	Y	W	G	Q	G	T	T	V	T	V	S	S	G	G	G	G	S	G	
	387			396			405			405		414			423			432	
	GGC	GGC	GGC	TCC	GGT	GGT	GGT	TCT	GAG	CTC	GTG	ATG	ACA	CAG	TCT	CCA	TCC		
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	G	G	G	S	G	G	G	S	E	L	V	M	T	Q	S	P	S		
	441			450			459			459		468			477			486	
	TCC	CTG	AGT	GTG	TCA	GCA	GGA	GAG	AAG	GTC	ACT	ATG	AGC	TGC	AAG	TCC	AGT	CAG	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	S	L	S	V	S	A	G	E	K	V	T	M	S	C	K	S	S	Q	
	495			504			513			513		522			531			540	
	AGT	CTG	TTA	AAC	AGT	GGA	AAT	CAA	AAG	AAC	TAC	TTG	GCC	TGG	TAC	CAG	CAG	AAA	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	S	L	L	N	S	G	N	Q	K	N	Y	L	A	W	Y	Q	Q	K	
	549			558			567			567		576			585			594	
	CCA	GGG	CAG	CCT	CCT	AAA	CTG	TTG	ATC	TAC	GGG	GCA	TCC	ACT	AGG	GAA	TCT	GGG	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	P	G	Q	P	P	K	L	L	I	Y	G	A	S	T	R	E	S	G	
	603			612			621			621		630			639			648	
	GTC	CCT	GAT	CGC	TTC	ACA	GGC	AGT	GGA	TCT	CGA	ACA	GAT	TTC	ACT	CTC	ACC	ATC	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	V	P	D	R	F	T	G	S	G	S	G	T	D	F	T	L	T	I	
	657			666			675			675		684			693			702	
	AGC	AGT	GTG	CAG	GCT	GAA	GAC	CTG	GCA	GTT	TAT	TAC	TGT	CAG	AAT	GAT	TAT	AGT	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	S	S	V	Q	A	E	D	L	A	V	Y	Y	C	Q	N	D	Y	S	
	711			720			729			729		738							
	TAT	CCG	TAC	ACG	TTC	GGG	-3'												
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	Y	P	Y	T	F	G	G	G	T	K	L	E	I	K					

Figure 6.7

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Figure 6.8

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		9		18		27		36		45		54						
5'	GAG	GTG	CAG	CTG	CTC	GAG	CAG	TCT	GGA	GCT	GAG	CTG	GCG	AGG	CCT	GGG	GCT	TCA
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	E	V	Q	L	L	E	Q	S	G	A	E	L	A	R	P	G	A	S
	63					72			81			90			99			108
	GTG	AAG	CTG	TCC	TGC	AAG	GCT	TCT	GGC	TAC	ACC	TTC	ACA	TAT	GGT	TTA	AGC	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	V	K	L	S	C	K	A	S	G	Y	T	F	T	N	Y	G	L	S
	117					126			135			144			153			162
	TGG	GTG	AAG	CAG	AGG	CCT	GGA	CAG	GTC	CTT	GAG	TGG	ATT	GGA	GAG	GTT	TAT	CCT
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	W	V	K	Q	R	P	G	Q	V	L	E	W	I	G	E	V	Y	P
	171					180			189			198			207			216
	AGA	ATT	GGT	AAT	GCT	TAC	TAC	AAT	GAG	AAG	TTC	AAG	GGC	AAG	GCC	ACA	CTG	ACT
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	R	I	G	N	A	Y	Y	N	E	K	F	K	G	K	A	T	L	T
	225					234			243			252			261			270
	GCA	GAC	AAA	TCC	TCC	AGC	ACA	GCG	TCC	ATG	GAG	CTC	CGC	AGC	CTG	ACC	TCT	GAG
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	A	D	K	S	S	S	T	A	S	M	E	L	R	S	L	T	S	E
	279			288				297			306			315			324	
	GAC	TCT	GCG	GTC	TAT	TTC	TGT	GCA	AGA	CGG	GGA	TCC	TAC	GAT	ACT	AAC	TAC	GAC
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	D	S	A	V	Y	F	C	A	R	R	G	S	Y	D	T	N	Y	D
	333					342			351			360			369			378
	TGG	TAC	TTC	GAT	GTC	TGG	GGC	CAA	GGG	ACC	ACG	GTC	ACC	GTC	TCC	TCA	GGT	GGT
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	W	Y	F	D	V	W	G	Q	G	T	T	V	T	V	S	S	G	G
	387					396			405			414			423			432
	GGT	GGT	TCT	GGC	GGC	GGC	TCC	GGT	GGT	GGT	GGT	TCT	GAG	CTC	GTG	ATG	ACC	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	G	G	S	G	G	G	S	G	G	G	G	S	E	L	V	M	T	
	441			450			459			468			477			486		
	CAG	ACT	CCA	CTC	TCC	CTG	CCT	GTC	AGT	CTT	GGA	GAT	CAA	GCC	TCC	ATC	TCT	TGC
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Q	T	P	L	S	L	P	V	S	L	G	D	Q	A	S	I	S	C
	495			504				513			522			531			540	
	AGA	TCT	AGT	CAG	AGC	CTT	GTA	CAC	AGT	AAT	GGA	AAC	ACC	TAT	TTA	CAT	TGG	TAC
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	R	S	S	Q	S	L	V	H	S	N	G	N	T	Y	L	H	W	Y
	549					558			567			576			585			594
	CTG	CAG	AAG	CCA	GGC	CAG	TCT	CCA	AAG	CTC	CTG	ATC	TAC	AAA	GTT	TCC	AAC	CGA
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	L	Q	K	P	G	Q	S	P	K	L	L	I	Y	K	V	S	N	R
	603					612			621			630			639			648
	TTT	TCT	GGG	CTC	CCA	GAC	AGG	TTC	AGT	GGC	AGT	GGA	TCA	GGG	ACA	GAT	TTC	ACA
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	F	S	G	V	P	D	R	F	S	G	S	G	S	G	T	D	F	T
	657					666			675			684			693			702
	CTC	AAG	ATC	AGC	AGA	GTG	GAG	GCT	GAG	GAT	CTG	GGA	GTT	TAT	TTC	TGC	TCT	CAA
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	L	K	I	S	R	V	E	A	E	D	L	G	V	Y	F	C	S	Q
	711					720			729			738			747			
	AGT	ACA	CAT	GTT	CCG	TAC	ACG	TTC	GGA	GGG	GGG	ACC	AAG	CTT	GAG	ATC	AAA	3'
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	S	T	H	V	P	Y	T	F	G	G	G	T	K	L	E	I	K	

Figure 6.9

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	9	18	27	36	45	54
GAG GTG CAG CTG CTC GAG TCT GGA GGT GGC CTG GTG CAG CCT GGA GGA TCC CTG						
E V Q L L E S G G G L V Q P G G S L						
63 72 81 90 99 108						
AAA CTC TCC TGT GCA GCC TCA GGA TTC GAT TTT AGT AGA TAC TGG ATG AGT TGG						
K L S C A A S G F D F S R Y W M S W						
117 126 135 144 153 162						
GTC CGG CAG GCT CCA GGG AAA GGG CTA GAA TGG ATT GGA GAA ATT AAT CCA GAT						
V R Q A P G K G L E W I G E I N P D						
171 180 189 198 207 216						
AGC AGT ACG ATA AAC TAT ACG CCA TCT CTG AAG GAT AAA TTC ATC ATC TCC AGA						
S S T I N Y T P S L K D K F I I S R						
225 234 243 252 261 270						
GAC AAC GCC AAA AAT ACG CTG TAC CTG CAA ATG GGC AAA GTG AGA TCT GAG GAC						
D N A K N T L Y L Q M G K V R S E D						
279 288 297 306 315 324						
ACA GCC CTT TAT TAC TGT GCA AGA GGA GCC TTC CTT TTT GAC TAC TGG GGC CAA						
T A L Y Y C A R G A F L F D Y W G Q						
333 342 351 360 369 378						
GGG ACC ACG GTC ACC GTC TCC TCA GGT GGT GGT GGT TCT GGC GGC GGC TCC						
G T T V T V S S G G G G S G G G G S						
387 396 405 414 423 432						
GGT GGT GGT TCT GAG CTC GTG CTC ACC CAG TCT CCA ACC ACC ATG GCT GCA						
G G G G S E L V L T Q S P T T M A A						
441 450 459 468 477 486						
TCT CCC GGG GAG AAG ATC ACT ATC ACC TGC AGT GCC AGC TCA AGT ATA AGT TCC						
S P G E K I T I T C S A S S S I S S						
495 504 513 522 531 540						
AAT TAC TTG CAT TGG TAT CAG CAG AAG CCA GGA TTC TCC CCT AAA CTC TTG ATT						
N Y L H W Y Q Q K P G F S P K L L I						
549 558 567 576 585 594						
TAT AGG ACA TCC AAT CTG GCT TCT GGA GTC CCA GCT CGC TTC AGT GGC AGT GGG						
Y R T S N L A S G V P A R F S G S G						
603 612 621 630 639 648						
TCT GGG ACC TCT TAC TCT CTC ACA ATT GGC ACC ATG GAG GCT GAA GAT GTT GCC						
S G T S Y S L T I G T M E A E D V A						
657 666 675 684 693 702						
ACT TAC TAC TGC CAG CAG GGT AGT AGT ATA CCA CTC ACG TTC GGT GCT GGG ACC						
T Y Y C Q Q G S S I P L T F G A G T						
711						
AAG CTT GAG ATC AAA 3'						
K L E I K						

Figure 6.10

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	9	18	27	36	45	54												
5'	GAG	GTG	CAG	CTG	CTC	GAG	CAG	TCT	GGA	GCT	GAG	CTG	GTA	AGG	CCT	GGG	ACT	TCA
	E	V	Q	L	L	E	Q	S	G	A	E	L	V	R	P	G	T	S
	63					72			81			90			99			108
	GTG	AAG	ATA	TCC	TGC	AAG	GCT	TCT	GGA	TAC	GCC	TTC	ACT	AAC	TAC	TGG	CTA	GGT
	V	K	I	S	C	K	A	S	G	Y	A	F	T	N	Y	W	L	G
	117					126			135			144			153			162
	TGG	GTA	AAG	CAG	AGG	CCT	GGA	CAT	GGA	CTT	GAG	TGG	ATT	GGA	GAT	ATT	TTC	CCT
	W	V	K	Q	R	P	G	H	G	L	E	W	I	G	D	I	F	P
	171					180			189			198			207			216
	GGA	AGT	GGT	AAT	ATC	CAC	TAC	AAT	GAG	AAG	TTC	AAG	GGC	AAA	GCC	ACA	CTG	ACT
	G	S	G	N	I	H	Y	N	E	K	F	K	G	K	A	T	L	T
	225					234			243			252			261			270
	GCA	GAC	AAA	TCT	TCG	AGC	ACA	GCC	TAT	ATG	CAG	CTC	AGT	AGC	CTG	ACA	TTT	GAG
	A	D	K	S	S	S	T	A	Y	M	Q	L	S	S	L	T	F	E
	279					288			297			306			315			324
	GAC	TCT	GCT	GTC	TAT	TTC	TGT	GCA	AGA	CTG	AGG	AAC	TGG	GAC	GAG	CCT	ATG	GAC
	D	S	A	V	Y	F	C	A	R	L	R	N	W	D	E	P	M	D
	333					342			351			360			369			378
	TAC	TGG	GGC	CAA	GGG	ACC	ACG	GTC	ACC	GTC	TCC	TCA	GGT	GGT	GGT	TCT	GGC	
	Y	W	G	Q	G	T	T	V	T	V	S	S	G	G	G	G	S	G
	387					396			405			414			423			432
	GGC	GGC	GGC	TCC	GGT	GGT	GGT	TCT	GAG	CTC	GTG	ATG	ACA	CAG	TCT	CCA	TCC	
	G	G	G	S	G	G	G	S	E	L	V	M	T	Q	S	P	S	
	441					450			459			468			477			486
	TCC	CTG	ACT	GTG	ACA	GCA	GGA	GAG	AAG	GTC	ACT	ATG	AGC	TGC	AAG	TCC	AGT	CAG
	S	L	T	V	T	A	G	E	K	V	T	M	S	C	K	S	S	Q
	495					504			513			522			531			540
	AGT	CTG	TTA	AAC	AGT	GGG	AAT	CAA	AAG	AAC	TAC	TTG	ACC	TGG	TAC	CAG	CAG	AAA
	S	L	L	N	S	G	N	Q	K	N	Y	L	T	W	Y	Q	Q	K
	549					558			567			576			585			594
	CCA	GGG	CAG	CCT	CCT	AAA	CTG	TTG	ATC	TAC	TGG	GCA	TCC	ACT	AGG	GAA	TCT	GGG
	P	G	Q	P	P	K	L	L	I	Y	W	A	S	T	R	E	S	G
	603					612			621			630			639			648
	GTC	CCT	GAT	CGC	TTC	ACA	GGC	AGT	GGA	TCT	GGA	ACA	GAT	TTC	ACT	CTC	ACC	ATC
	V	P	D	R	F	T	G	S	G	S	G	T	D	F	T	L	T	I
	657					666			675			684			693			702
	AGC	AGT	GTG	CAG	GCT	GAA	GAC	CTG	GCA	GTT	TAT	TAC	TGT	CAG	AAT	GAT	TAT	AGT
	S	S	V	Q	A	E	D	L	A	V	Y	Y	C	Q	N	D	Y	S
	711					720			729			738						
	TAT	CCG	CTC	ACG	TTC	GGT	GCT	GGG	ACC	AAG	CTT	GAG	ATC	AAA	3'			
	Y	P	L	T	F	G	A	G	T	K	L	E	I	K				

Figure 7

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	9	18	27	36	45	54												
5'	GAG	GTG	CAG	CTG	CTC	GAG	CAG	TCT	GGA	GCT	GAG	CTG	GTA	AGG	CCT	GGG	ACT	TCA
	E	V	Q	L	L	E	Q	S	G	A	E	L	V	R	P	G	T	S
	63					72			81			90			99			108
	GTG	AAG	ATA	TCC	TGC	AAG	GCT	TCT	GGA	TAC	GCC	TTC	ACT	AAC	TAC	TGG	CTA	GGT
	V	K	I	S	C	K	A	S	G	Y	A	F	T	N	Y	W	L	G
	117					126			135			144			153			162
	TGG	GTT	AAG	CAG	AGG	CCT	GGA	CAT	GGA	CTT	GAA	TGG	GTT	GGA	GAT	ATT	TTC	CCT
	W	V	K	Q	R	P	G	H	G	L	E	W	V	G	D	I	F	P
	171					180			189			198			207			216
	GGA	AGT	GGT	AAT	GCT	CAC	TAC	AAT	GAG	AAG	TTC	AAG	GGC	AAA	GCC	ACA	CTG	ACT
	G	S	G	N	A	H	Y	N	E	K	F	K	G	K	A	T	L	T
	225					234			243			252			261			270
	GCA	GAC	AAG	TCC	TCG	TAC	ACA	GCC	TAT	ATG	CAG	CTC	AGT	AGC	CTG	ACA	TCT	GAG
	A	D	K	S	S	Y	T	A	Y	M	Q	L	S	S	L	T	S	E
	279					288			297			306			315			324
	GAC	TCT	GCT	GTC	TAT	TTC	TGT	GCA	AGA	TTG	CGG	AAC	TGG	GAC	GAG	GCT	ATG	GAC
	D	S	A	V	Y	F	C	A	R	L	R	N	W	D	E	A	M	D
	333					342			351			360			369			378
	TAC	TGG	GGC	CAA	GGG	ACC	ACG	GTC	ACC	GTC	TCC	TCA	GGT	GGT	GGT	GGT	TCT	GGC
	Y	W	G	Q	G	T	T	V	T	V	S	S	G	G	G	G	S	G
	387					396			405			414			423			432
	GGC	GGC	GGC	TCC	GGT	GGT	GGT	TCT	GAG	CTC	GTG	ATG	ACA	CAG	TCT	CCA	TCC	
	G	G	G	S	G	G	G	S	E	L	V	M	T	Q	S	P	S	
	441					450			459			468			477			486
	TCC	CTG	GCT	ATG	TCA	GTA	GGA	CAG	AAG	GTC	ACT	ATG	AGC	TGC	AAG	TCC	AGT	CAG
	S	L	A	M	S	V	G	Q	K	V	T	M	S	C	K	S	S	Q
	495					504			513			522			531			540
	AGC	CTT	TTA	AAT	AGT	AGC	AAT	CAA	AAG	AAC	TAT	TTG	GCC	TGG	TAC	CAG	CAG	AAA
	S	L	L	N	S	S	N	Q	K	N	Y	L	A	W	Y	Q	Q	K
	549					558			567			576			585			594
	CAA	GGG	CAG	CCT	CCT	AAA	CTG	CTT	ATC	TAT	GGG	GCA	TCC	ATT	AGA	GAA	TCT	TGG
	Q	G	Q	P	P	K	L	L	I	Y	G	A	S	I	R	E	S	W
	603					612			621			630			639			648
	GTC	CCT	GAT	CGA	TTC	ACA	GGA	AGT	GGA	TCT	GGG	ACA	GAC	TTC	ACT	CTC	ACC	ATC
	V	P	D	R	F	T	G	S	G	S	G	T	D	F	T	L	T	I
	657					666			675			684			693			702
	AGC	AGT	GTG	AAG	GCT	GAA	GAC	CTG	GCA	GTT	TAT	TAC	TGT	CAG	CAA	TAT	TAT	AGC
	S	S	V	K	A	E	D	L	A	V	Y	Y	C	Q	Q	Y	Y	S
	711					720			729			738						
	TAT	CCG	TAC	ACG	TTC	GGA	GGG	GGG	ACC	AAG	CTT	GAG	ATC	AAA	3'			
	Y	P	Y	T	F	G	G	G	T	K	L	E	I	K				

Figure 8.1

ELISA -analysis  
CD 80-Anti-17-1A scFv 3-1 – 5-13 (PS)  
Detection: anti – CD 80

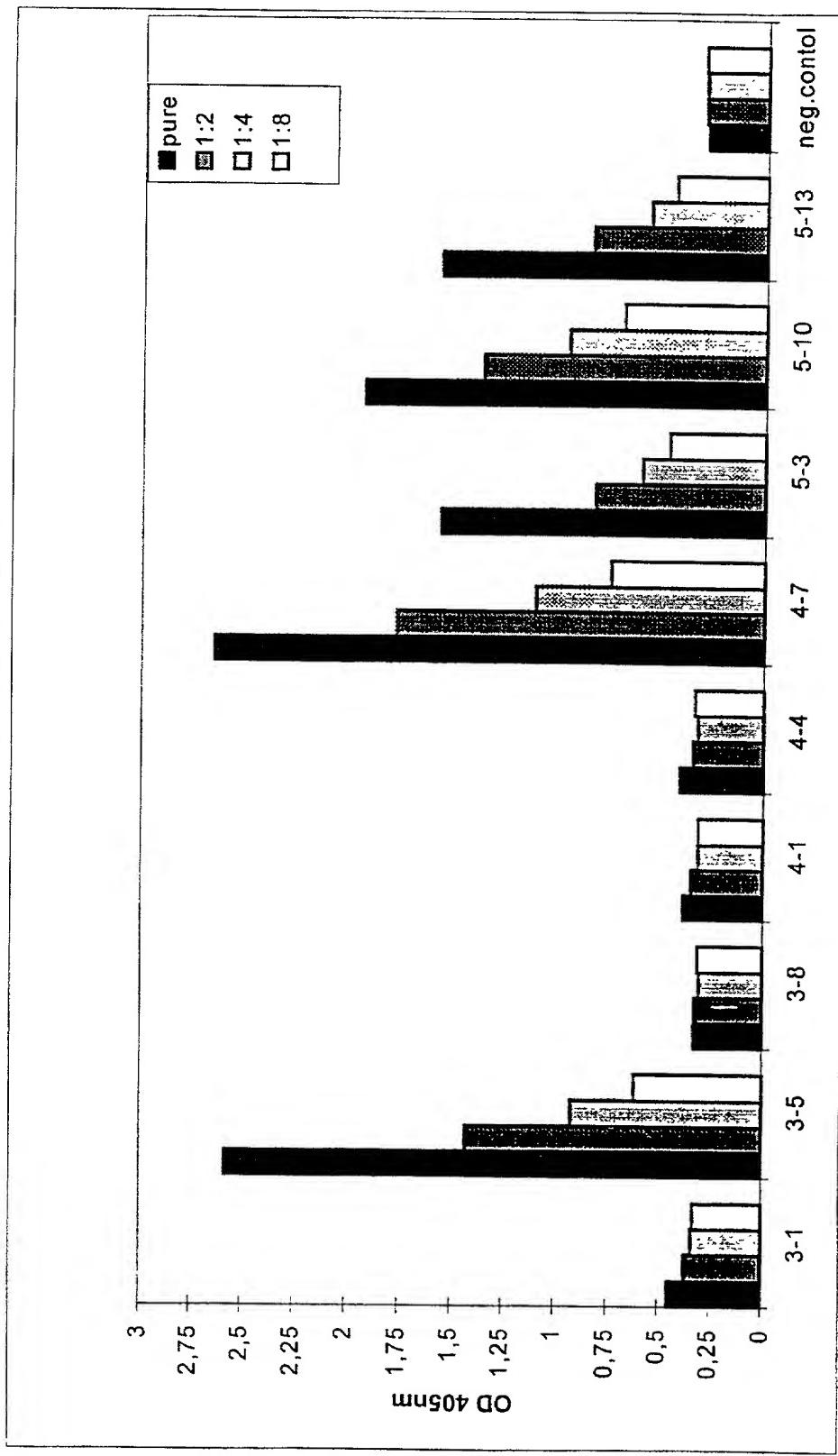


Figure 8.2.

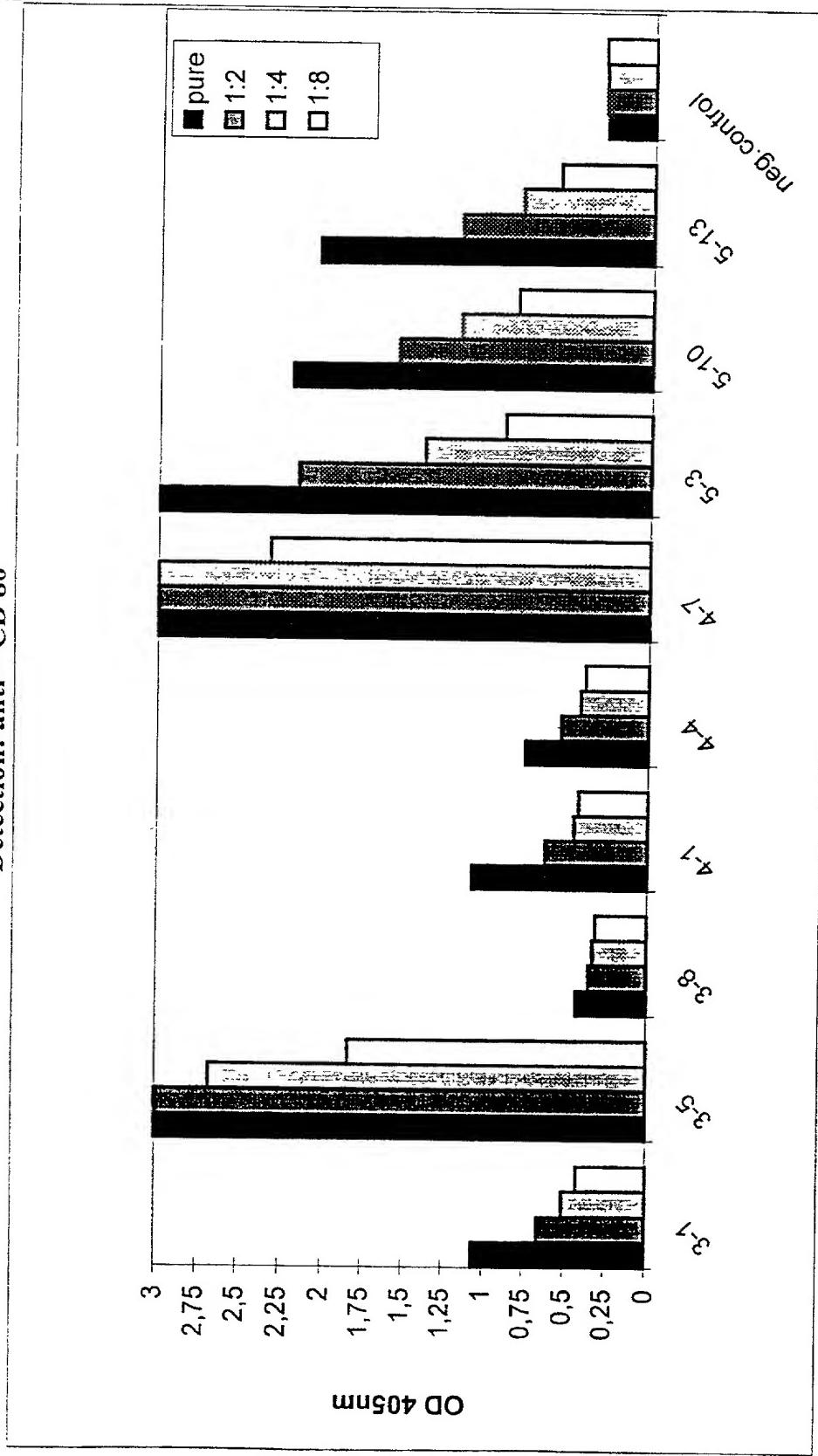
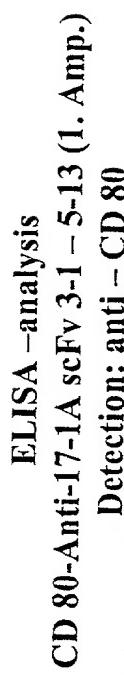


Figure 8.3

ELISA -analysis  
CD 80-VD4.5V<sub>k</sub>8 scFv (PS) and CD 80-Mach scFv (PS)  
Detection: anti - CD 80

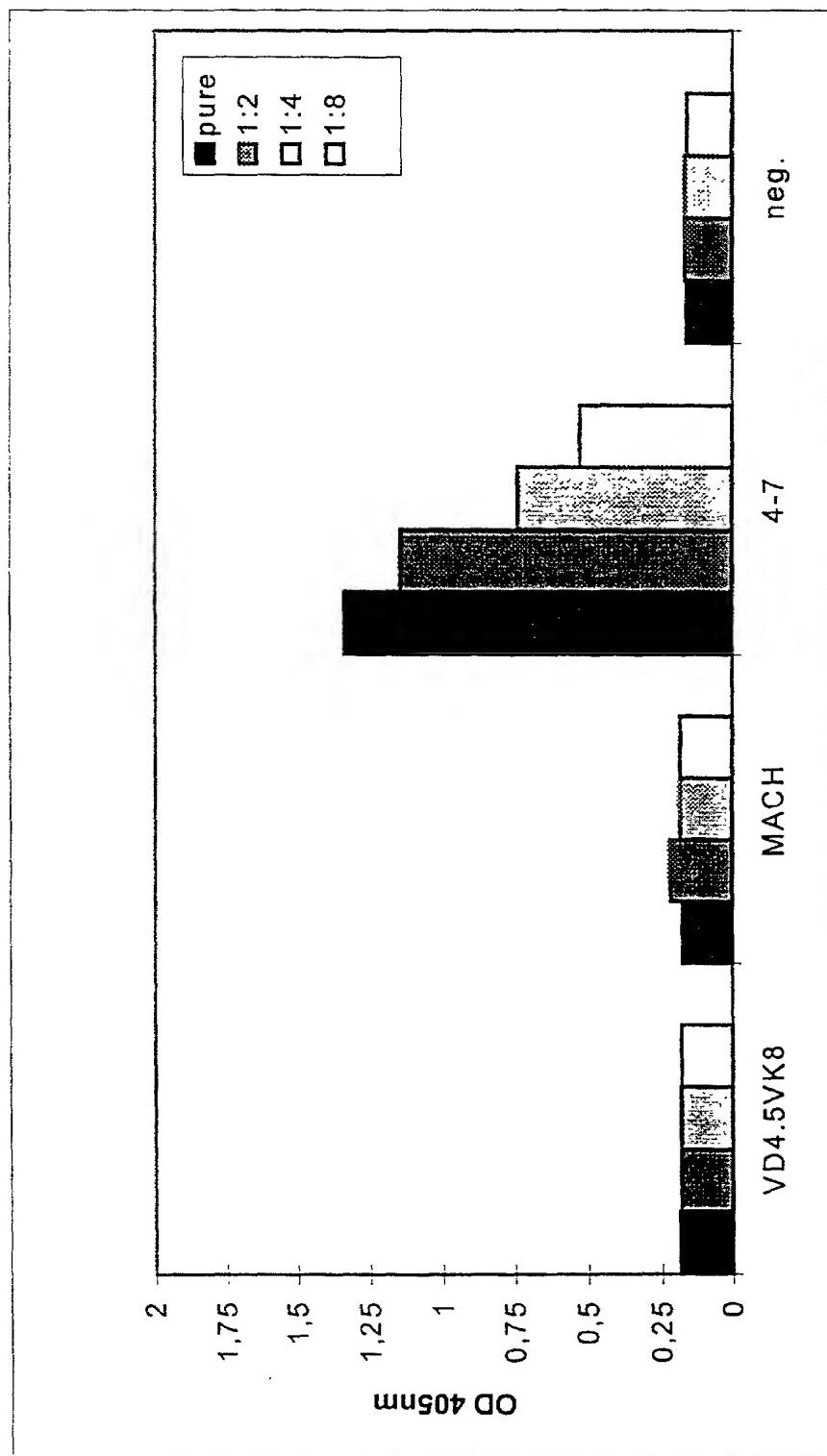


Figure 8.4

ELISA -analysis  
CD 80-VD4.5V<sub>k</sub>8 scFv (1. Amp.) and CD 80-Mach scFv (1. Amp.)  
Detection: anti - CD 80

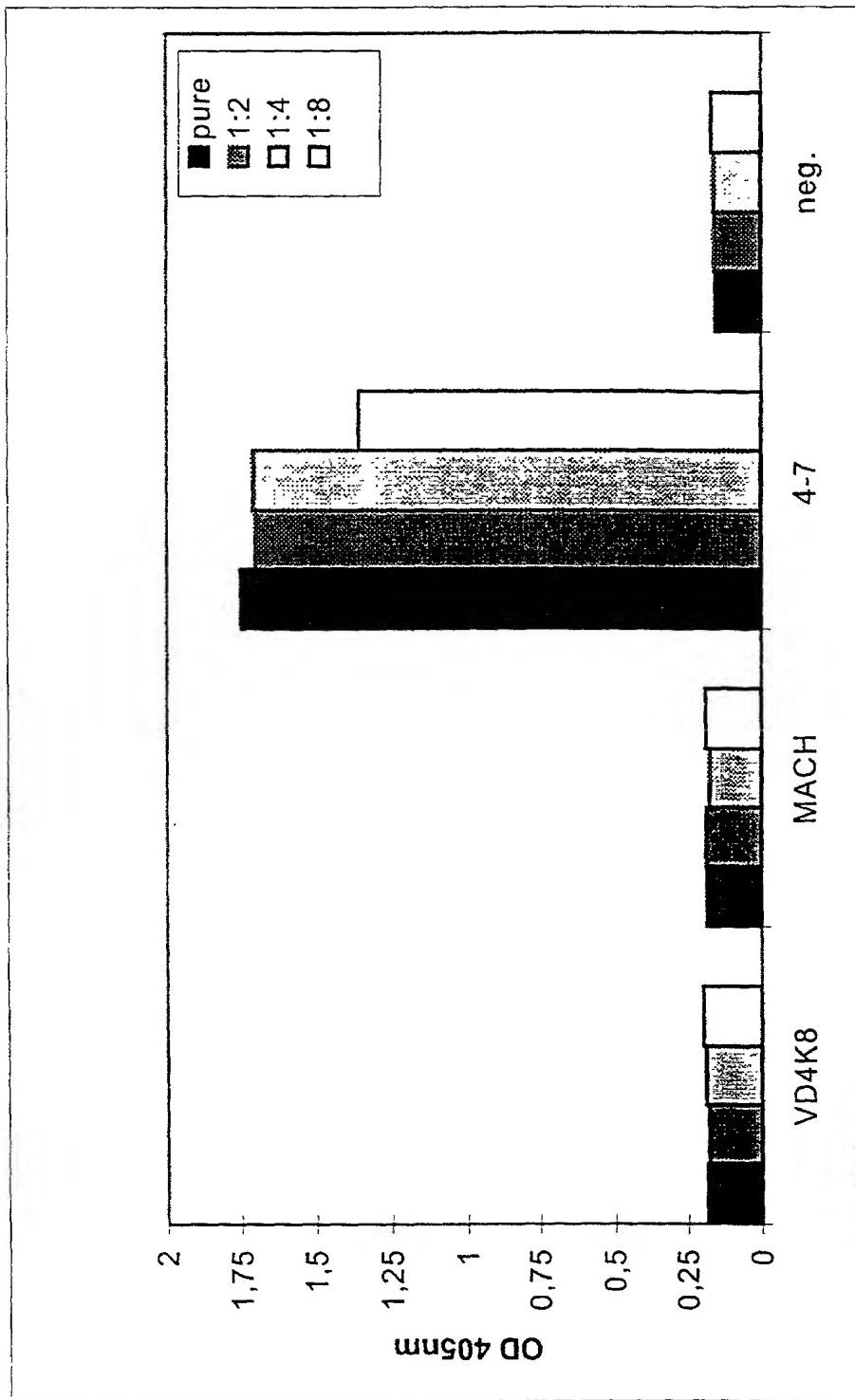


Figure 9.1

Part 1

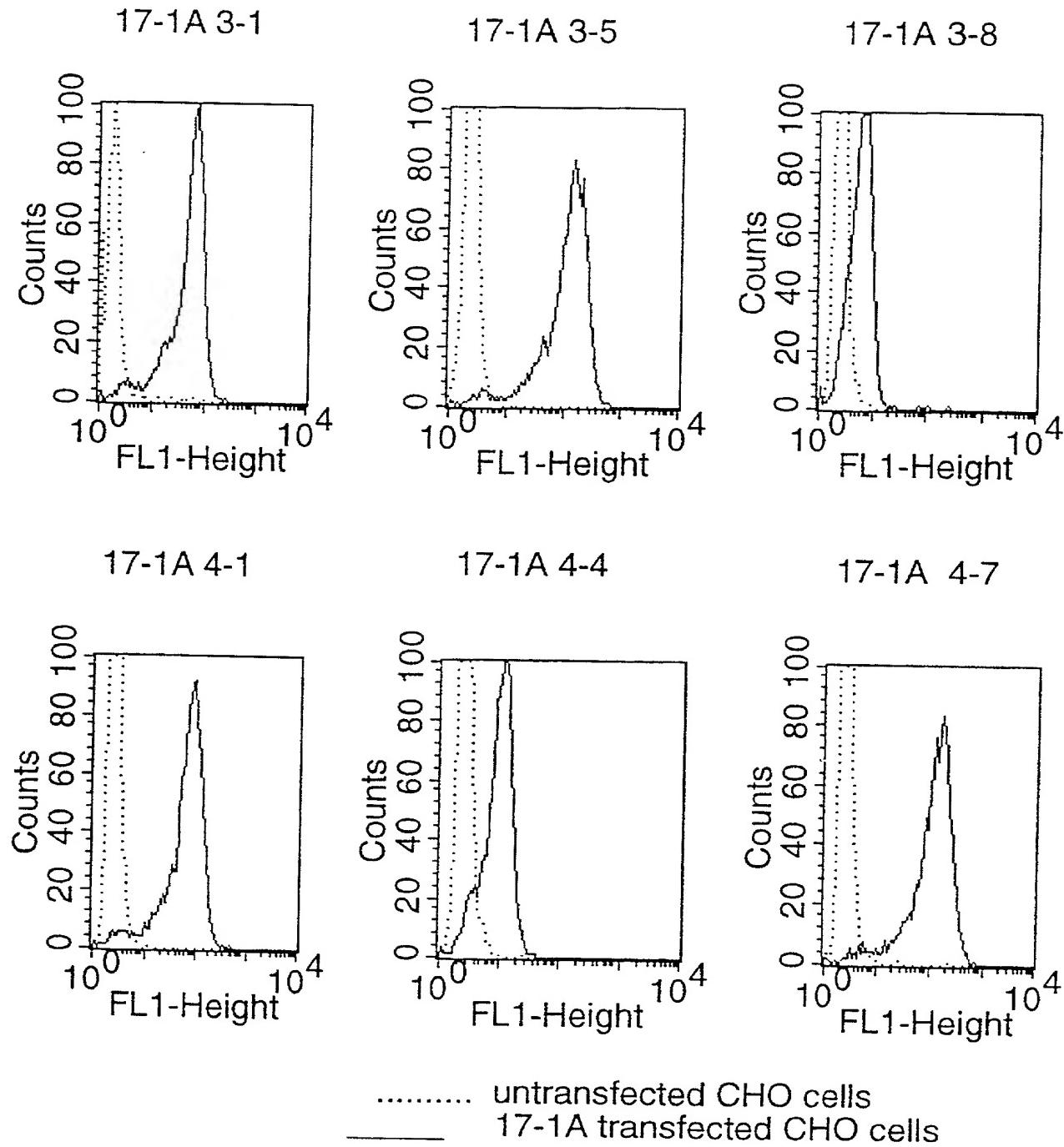


Figure 9.1

Part 2

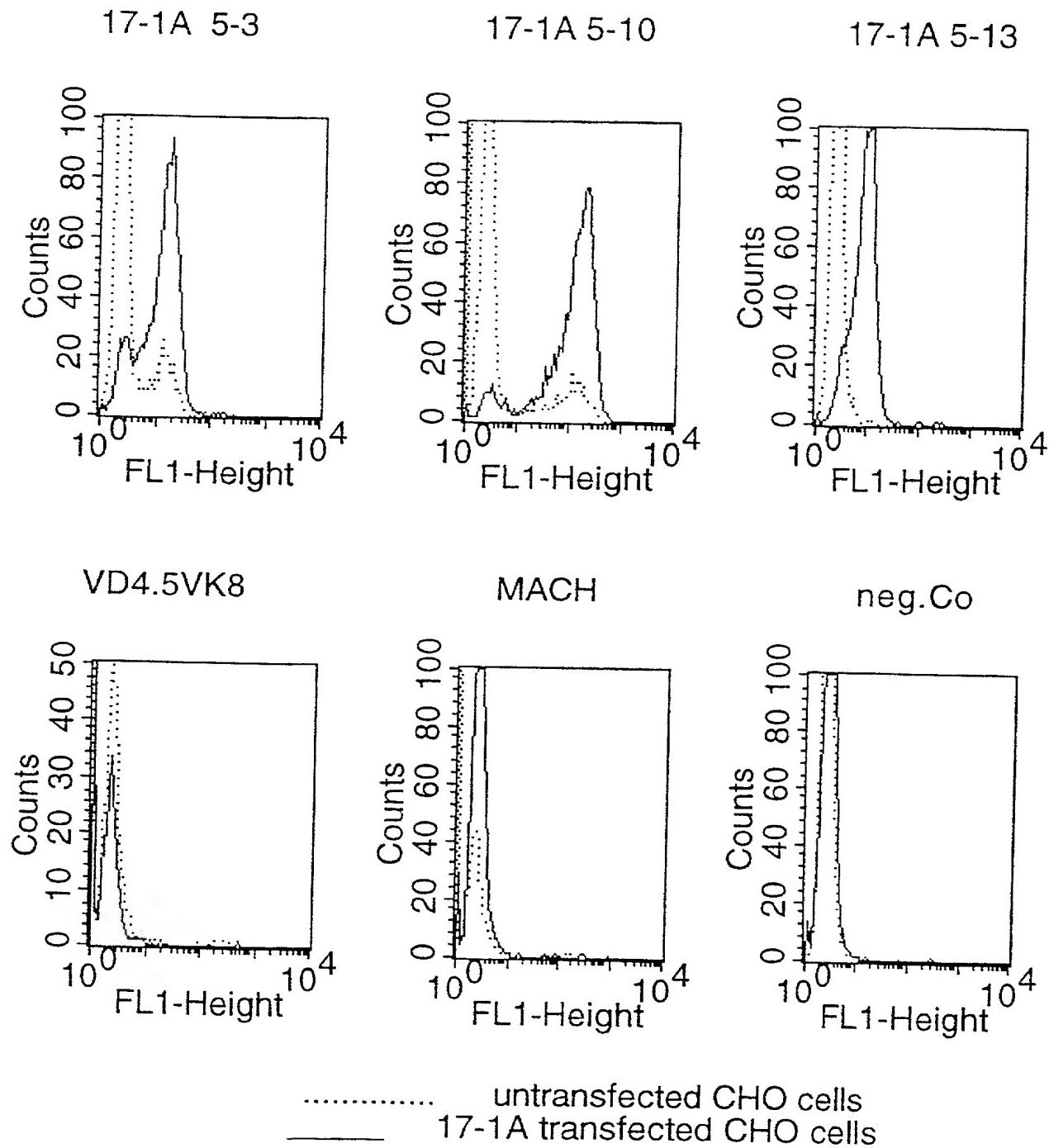


Figure 9.2

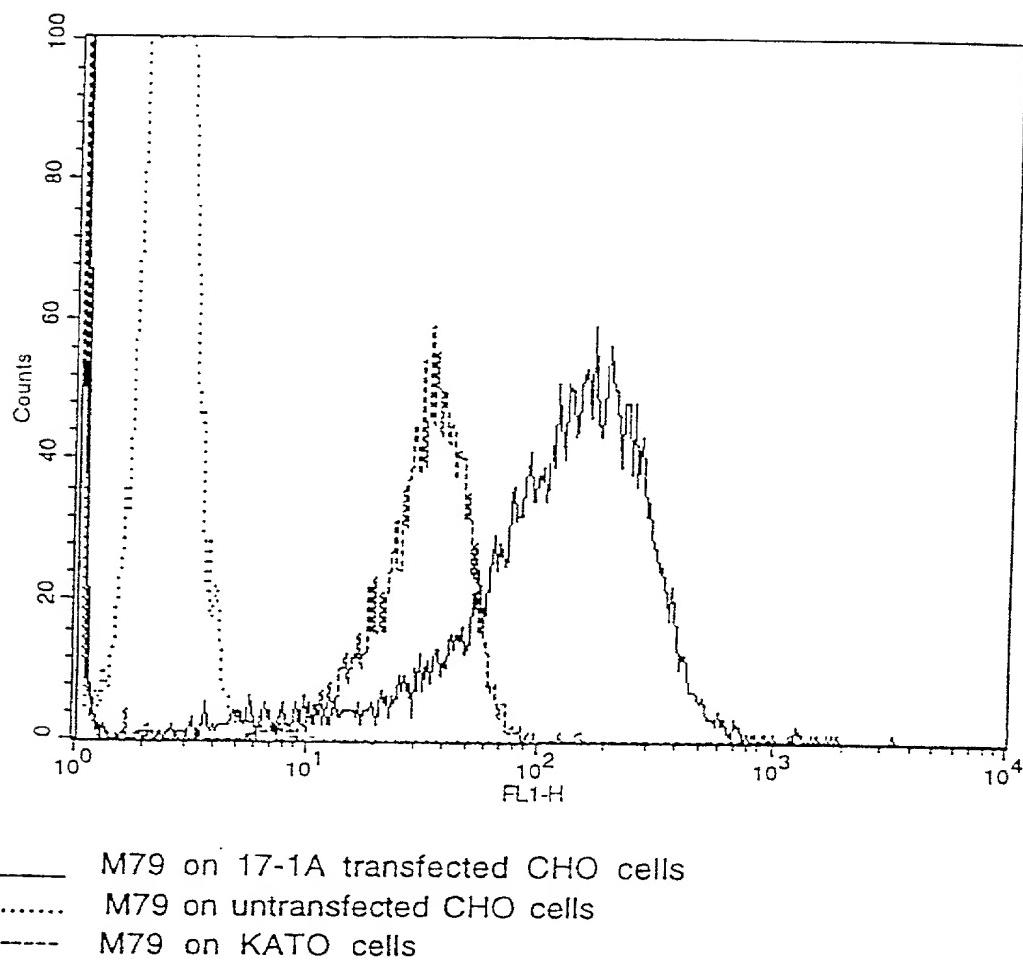
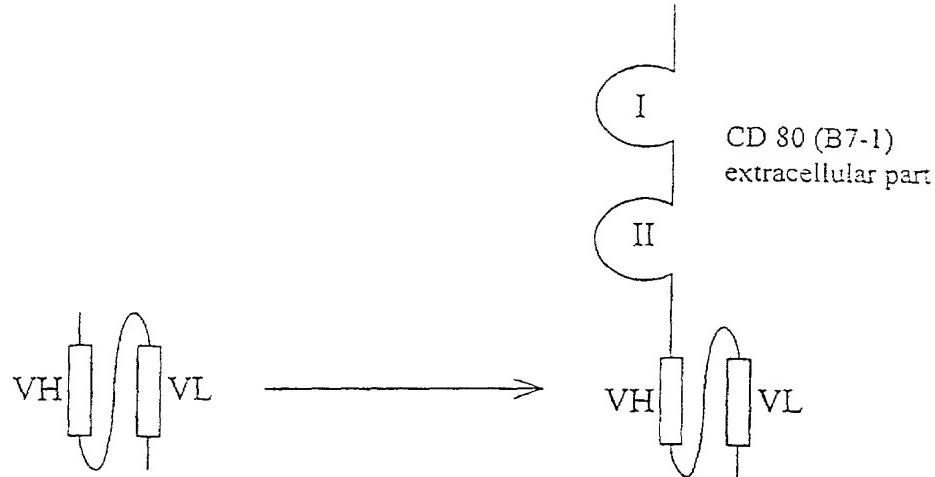


Figure 10

## 1) The Conventional approach

Randomly selected antigen-specific VH/VL-pairs that bind to their antigen as free or N-terminally located scFv-fragments or as whole antibody molecules

Frequent loss of antigen binding after fusion of another protein domain to the N-terminus of the scFv-fragment



## 2) The method of invention

VH/VL-pairs selected by the method of the invention

High frequency of antigen binding after fusion of another protein domain to the N-terminus of the scFv-fragment

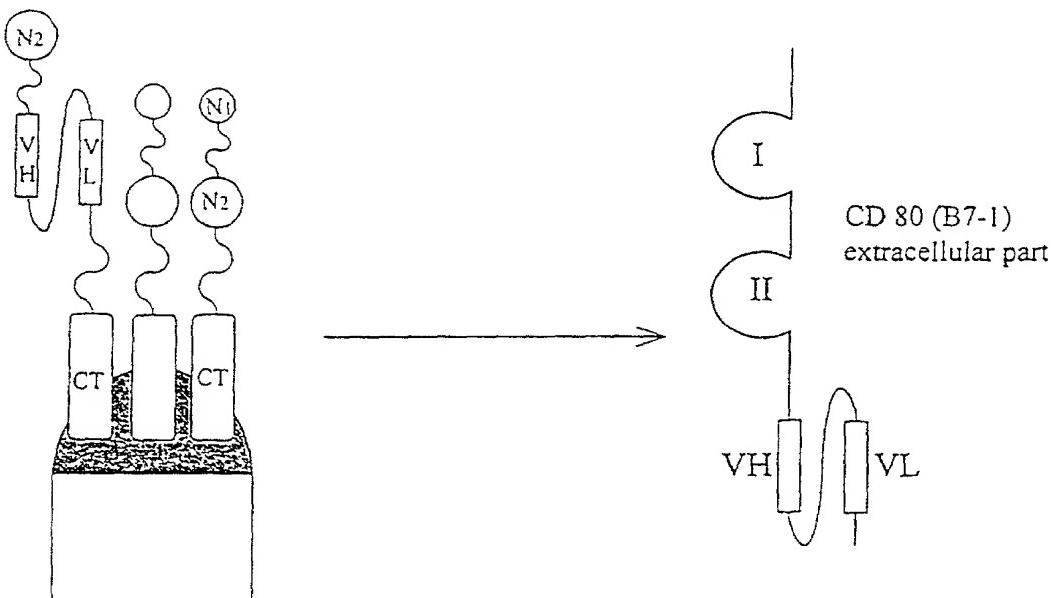


Figure 11

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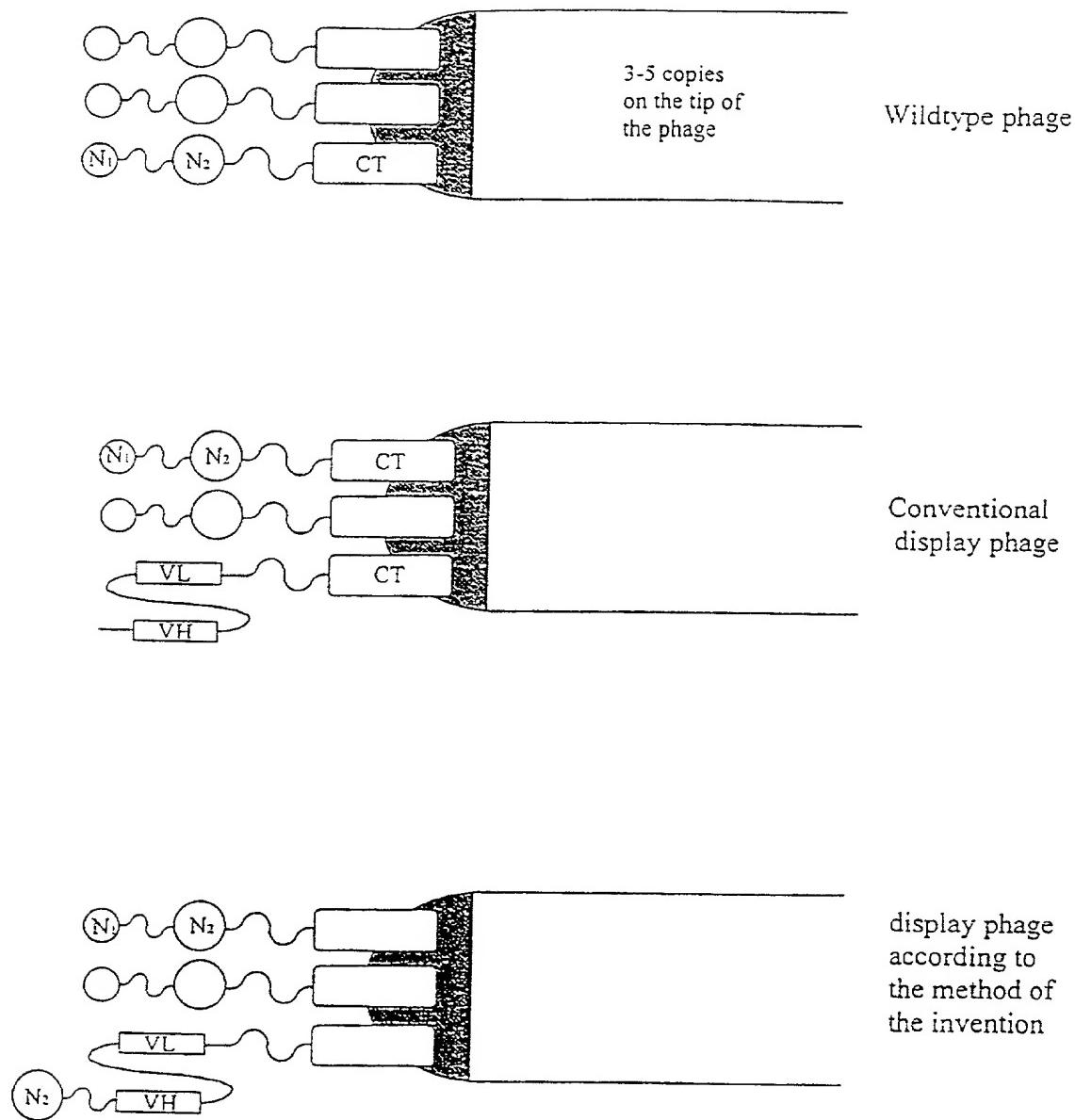
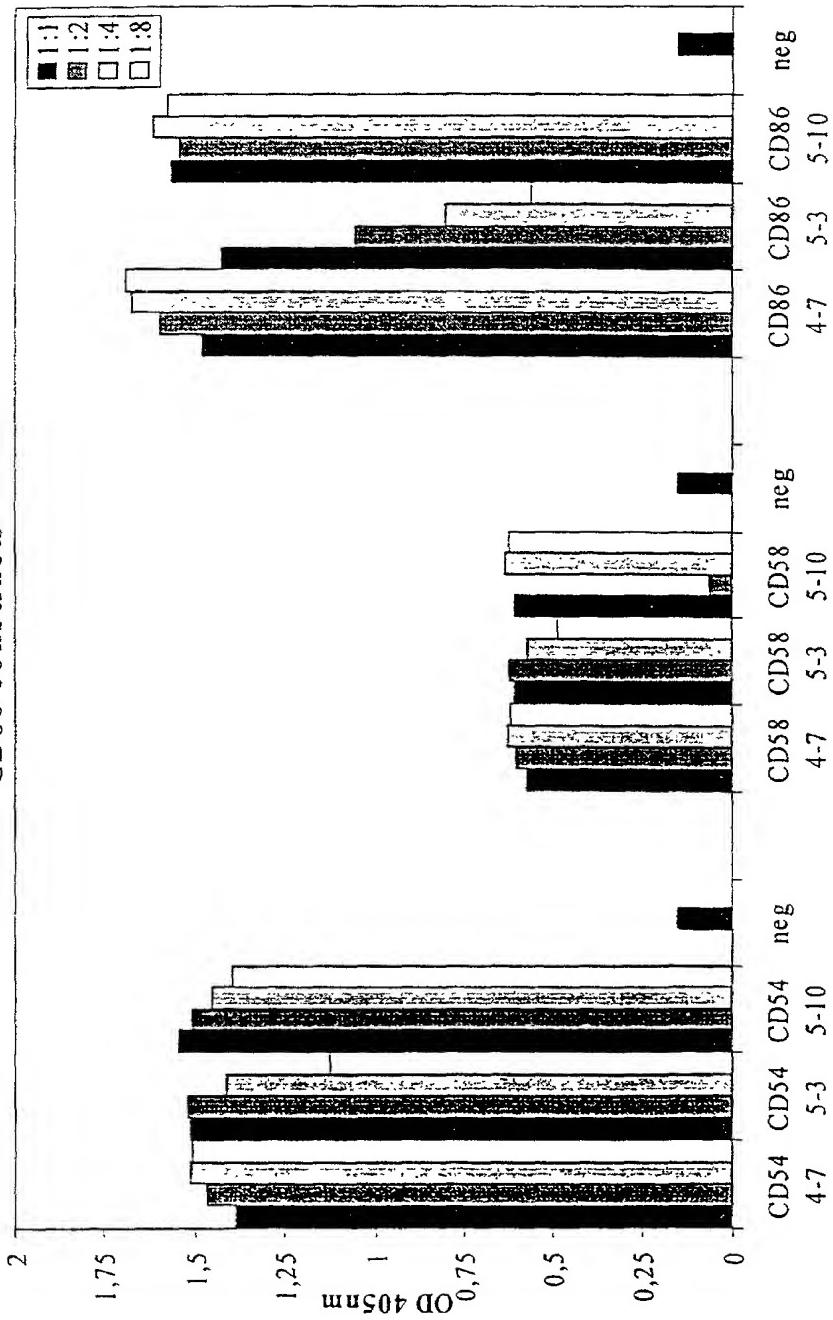


Figure 12

## ELISA on different anti 17-1A-CD54, anti 17-1A CD58, anti 17-1A

## CD86 constructs





Attorney Docket No. 147-199P

I hereby appoint the following attorneys to prosecute this application and/or an international application based on this application and to transact all business in the Patent and Trademark Office connected therewith and in connection with the resulting patent base, on instructions received from the entity who first sent the application papers to the attorneys identified below, unless the inventor(s) or assignee provides said attorneys with a written notice to the contrary:

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John W. Bailly (Reg. No. 32,881)	John A. Castellano (Reg. No. 35,094)
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FOLLOWING:**  
↓

Full Name of First  
Inventor:  
Inventor's Name of  
Inventor Date This  
Document is Signed

Inventor Residence  
Inventor Citizenship

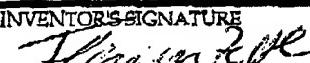
Inventor Post Office  
Address

Full Name of Second  
Inventor, if any:  
see above

Full Name of Third  
Inventor, if any:  
see above

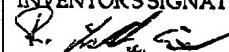
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see above

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

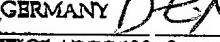
GIVEN NAME/FAMILY NAME <u>Peter KUFE</u>		INVENTOR'S SIGNATURE 	DATE* <u>09/27/2000</u>
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Attorney Docket No. 147-199P.

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Inventor, if any:  
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GIVEN NAME/FAMILY NAME	INVENTOR'S SIGNATURE	DATE*
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CITIZENSHIP

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Full Name of Tenth  
Inventor, if any:  
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GIVEN NAME/FAMILY NAME	INVENTOR'S SIGNATURE	DATE*
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Inventor, if any:  
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Inventor, if any:  
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Residence (City, State &amp; Country)

CITIZENSHIP

POST OFFICE ADDRESS (Complete Street Address including City, State &amp; Country)

## SEQUENCE LISTING

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<120> A novel method of identifying binding site domains that  
retain the capacity of binding to an epitope

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<150> EP 97 12 0096.9

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27

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<212> DNA

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27

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**15/48**

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27

&lt;210&gt; 38

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&lt;400&gt; 38

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27

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&lt;400&gt; 39

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34

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32

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19/48

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cattgag

67

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5

10

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21/48

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Ser Leu Arg Leu Ser Cys Ala Ala Ser Gly Phe Thr Phe Ser Ser Tyr  
20 25 30

Gly Met His Trp Val Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Val  
35 40 45

Ala Val Ile Ser Tyr Asp Gly Ser Asn Lys Tyr Tyr Ala Asp Ser Val  
50 55 60

Lys Gly Arg Phe Thr Ile Ser Arg Asp Asn Ser Lys Asn Thr Leu Tyr  
65 70 75 80

Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys  
85 90 95

22/48

Ala Lys Asp Met Gly Trp Gly Ser Gly Trp Arg Pro Tyr Tyr Tyr Tyr

100

105

110

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115

120

125

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<213> Homo sapiens

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5

10

15

23/48

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Leu Asn Trp Tyr Gln Gln Lys Pro Gly Gln Pro Pro Lys Leu Leu Ile

35 40 45

Tyr Trp Ala Ser Thr Arg Glu Ser Gly Val Pro Asp Arg Phe Ser Gly

50 55 60

Ser Gly Ser Gly Thr Asp Phe Thr Leu Thr Ile Ser Ser Leu Gln Pro

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85 90 95

Thr Phe Gly Gln Gly Thr Lys Leu Glu Ile Lys

100 105

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<400> 57

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<213> M13-Phage and artificial sequence of the MCS

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cctaattcatt ctcttgagga gtctcagcct cttaataactt tcatgtttca gaataatagg 180  
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cccgtaaaaa cttattacca gtacactcct gtatcatcaa aagccatgta tgacgcttac 300  
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ggTGGATCCG aggtgcagct gctcgagccc ggtcacCGTC tcctcaggtg gtggtggttc 480  
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Ile Asn Pro Leu Asp Gly Thr Tyr Pro Pro Gly Thr Glu Gln Asn Pro  
20 25 30

Ala Asn Pro Asn Pro Ser Leu Glu Glu Ser Gln Pro Leu Asn Thr Phe  
35 40 45

Met Phe Gln Asn Asn Arg Phe Arg Asn Arg Gln Gly Ala Leu Thr Val  
50 55 60

Tyr Thr Gly Thr Val Thr Gln Gly Thr Asp Pro Val Lys Thr Tyr Tyr  
65 70 75 80

Gln Tyr Thr Pro Val Ser Ser Lys Ala Met Tyr Asp Ala Tyr Trp Asn  
85 90 95

Gly Lys Phe Arg Asp Cys Ala Phe His Ser Gly Phe Asn Glu Asp Pro  
100 105 110

Phe Val Cys Glu Tyr Gln Gly Gln Ser Ser Asp Leu Pro Gln Pro Pro  
115 120 125

Val Asn Ala Ser Gly Gly Gly Ser  
130 135

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<400> 60

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aggcctggac atggacttga gtggattgga gatctttcc ctggaagtgg taatactcac 180  
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cagtctccat cttatcttgc tgcatttcct ggagaaacca ttactattaa ttgcagggca 480  
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cttcttatct actctggatc cactttgcaa tctggaattc catcaaggtt cagttggcagt 600  
ggatctggta cagatttcac tctcaccatc agtagcctgg agcctgaaga ttttgcattg 660  
tattactgtc aacagcataa tgaatatccg tacacgttcg gaggggggac caagcttgag 720  
atcaaa 726

<210> 61

<211> 242

<212> PRT

<213> Mus sp.

<400> 61

Glu Val Gln Leu Leu Glu Gln Ser Gly Ala Glu Leu Val Lys Pro Gly

27/48

Ala Ser Val Lys Ile Ser Cys Lys Ala Ser Gly Tyr Ala Phe Thr Asn

20 25 30

Tyr Trp Leu Gly Trp Val Lys Gln Arg Pro Gly His Gly Leu Glu Trp

35 40 45

Ile Gly Asp Leu Phe Pro Gly Ser Gly Asn Thr His Tyr Asn Glu Arg

50 55 60

Phe Arg Gly Lys Ala Thr Leu Thr Ala Asp Lys Ser Ser Ser Thr Ala

65 70 75 80

Phe Met Gln Leu Ser Ser Leu Thr Ser Glu Asp Ser Ala Val Tyr Phe

85 90 95

Cys Ala Arg Leu Arg Asn Trp Asp Glu Ala Met Asp Tyr Trp Gly Gln

100 105 110

Gly Thr Thr Val Thr Val Ser Ser Gly Gly Gly Ser Gly Gly Gly

115 120 125

Gly Ser Gly Gly Ser Glu Leu Val Met Thr Gln Ser Pro Ser

130 135 140

Tyr Leu Ala Ala Ser Pro Gly Glu Thr Ile Thr Ile Asn Cys Arg Ala

145 150 155 160

Ser Lys Ser Ile Ser Lys Tyr Leu Ala Trp Tyr Gln Glu Lys Pro Gly

165 170 175

28/48

Lys Thr Asn Lys Leu Leu Ile Tyr Ser Gly Ser Thr Leu Gln Ser Gly

180

185

190

Ile Pro Ser Arg Phe Ser Gly Ser Gly Ser Gly Thr Asp Phe Thr Leu

195

200

205

Thr Ile Ser Ser Leu Glu Pro Glu Asp Phe Ala Met Tyr Tyr Cys Gln

210

215

220

Gln His Asn Glu Tyr Pro Tyr Thr Phe Gly Gly Thr Lys Leu Glu

225

230

235

240

Ile Lys

<210> 62

<211> 753

<212> DNA

<213> Mus sp.

<400> 62

gaggtgcagc tgctcgagca gtctggagct gagctggtaa ggccctggac ttcagtgaag 60

ctgtcctgca aggcttctgg ctacaccc tc acaagctatg gtttaagctg ggtgaagcag 120

agaactggac agggccttga gtggatttga gaggttatac ctagaatttg taatgcttac 180

tacaatgaga agttcaaggg caaggccaca ctgactgcag acaaattcctc cagcacagcg 240

tccatggagc tccgcagcct gacatctgag gactctgcgg tctatttctg tgcaagacgg 300

ggatcctacg gtagtaacta cgactggta ttcgatgtct ggggccaagg gaccacggc 360

accgtctcct caggtggtgg tggttctggc ggccggccgtt ccgggtggtgg tggttctgag 420

29/48

ctcgtgatga cccagactcc actctccctg cctgtcagtc ttggagatca agcctccatc 480  
tcttgcatat ctatgcacat cttgtacac agtaatggaa acacctattt acattggtag 540  
ctgcagaagc caggccagtc tccaaagctc ctgatctaca aagtttccaa ccgattttct 600  
ggggtcccag acaggttcag tggcagtgga tcagggacag atttcacact caagatcagc 660  
agagtggagg ctgaggatct gggagtttat ttctgctctc aaagtacaca tgttccgtac 720  
acgttcggag gggggaccaa gcttgagatc aaa 753

&lt;210&gt; 63

&lt;211&gt; 251

&lt;212&gt; PRT

&lt;213&gt; Mus sp.

&lt;400&gt; 63

Glu Val Gln Leu Leu Glu Gln Ser Gly Ala Glu Leu Val Arg Pro Gly  
1 5 10 15

Thr Ser Val Lys Leu Ser Cys Lys Ala Ser Gly Tyr Thr Phe Thr Ser  
20 25 30

Tyr Gly Leu Ser Trp Val Lys Gln Arg Thr Gly Gln Gly Leu Glu Trp  
35 40 45

Ile Gly Glu Val Tyr Pro Arg Ile Gly Asn Ala Tyr Tyr Asn Glu Lys  
50 55 60

Phe Lys Gly Lys Ala Thr Leu Thr Ala Asp Lys Ser Ser Ser Thr Ala  
65 70 75 80

Ser Met Glu Leu Arg Ser Leu Thr Ser Glu Asp Ser Ala Val Tyr Phe

**30/48**

85                    90                    95

Cys Ala Arg Arg Gly Ser Tyr Gly Ser Asn Tyr Asp Trp Tyr Phe Asp

100                  105                  110

Val Trp Gly Gln Gly Thr Thr Val Thr Val Ser Ser Gly Gly Gly

115                  120                  125

Ser Gly Gly Gly Ser Gly Gly Gly Ser Glu Leu Val Met Thr

130                  135                  140

Gln Thr Pro Leu Ser Leu Pro Val Ser Leu Gly Asp Gln Ala Ser Ile

145                  150                  155                  160

Ser Cys Arg Ser Ser Gln Ser Leu Val His Ser Asn Gly Asn Thr Tyr

165                  170                  175

Leu His Trp Tyr Leu Gln Lys Pro Gly Gln Ser Pro Lys Leu Leu Ile

180                  185                  190

Tyr Lys Val Ser Asn Arg Phe Ser Gly Val Pro Asp Arg Phe Ser Gly

195                  200                  205

Ser Gly Ser Gly Thr Asp Phe Thr Leu Lys Ile Ser Arg Val Glu Ala

210                  215                  220

Glu Asp Leu Gly Val Tyr Phe Cys Ser Gln Ser Thr His Val Pro Tyr

225                  230                  235                  240

Thr Phe Gly Gly Thr Lys Leu Glu Ile Lys

245

250

&lt;210&gt; 64

&lt;211&gt; 726

&lt;212&gt; DNA

&lt;213&gt; Mus sp.

&lt;400&gt; 64

gaggtgcagc tgctcgagca gtctggagct gcgcgtggtaa ggccctggac ttcagtgaag 60  
atatcctgca aggcttctgg atacgccttc actaactact ggcttaggttg ggtaaaggcag 120  
aggcctggac atggacttga gtggattgga gatatttacc ctggaagtgg taatactcac 180  
tacaatgaga gtttcagggg caaagccaca ctgactgcag acaaattcctc gagcacagcc 240  
tttatgcagc tcagtagcct gacatctgag gactctgctg tctatttcgt tgcaagattg 300  
aggaactggg acgagccat ggactactgg ggccaaggga ccacggtcac cgtctcctca 360  
ggtgtggtg gttctggcgg cggcggctcc ggtgggtggtg gttctgagct ccagatgacc 420  
cagtctccat cttatcttgc tgcatttcct ggagaaaacca ttactattaa ttgcagggca 480  
agtaagagca ttagcaaata tttagcctgg tatcaagaga aacctggaa aactaataag 540  
cttcttatct actctggatc cactttgcaa tctggattc catcaagggtt cagttggcagt 600  
ggatctggta cagatttcac tctcaccatc agtagcctgg agcctgaaga ttttgcaatg 660  
tattactgtc aacagcataa tgaatacccg tacacgttcg gaggggggac caagcttgag 720  
atcaaa 726

&lt;210&gt; 65

&lt;211&gt; 242

&lt;212&gt; PRT

&lt;213&gt; Mus sp.

&lt;400&gt; 65

**32/48**

Glu Val Gln Leu Leu Glu Gln Ser Gly Ala Ala Leu Val Arg Pro Gly

1

5

10

15

Thr Ser Val Lys Ile Ser Cys Lys Ala Ser Gly Tyr Ala Phe Thr Asn

20

25

30

Tyr Trp Leu Gly Trp Val Lys Gln Arg Pro Gly His Gly Leu Glu Trp  
35                   40                   45

Ile Gly Asp Ile Tyr Pro Gly Ser Gly Asn Thr His Tyr Asn Glu Arg

50

55

60

Phe Arg Gly Lys Ala Thr Leu Thr Ala Asp Lys Ser Ser Ser Thr Ala

65

70

75

80

Phe Met Gln Leu Ser Ser Leu Thr Ser Glu Asp Ser Ala Val Tyr Phe

85

90

95

Cys Ala Arg Leu Arg Asn Trp Asp Glu Pro Met Asp Tyr Trp Gly Gln

100

105

110

Gly Thr Thr Val Thr Val Ser Ser Gly Gly Gly Ser Gly Gly Gly

115

120

125

Gly Ser Gly Gly Ser Glu Leu Gln Met Thr Gln Ser Pro Ser

130

135

140

Tyr Leu Ala Ala Ser Pro Gly Glu Thr Ile Thr Ile Asn Cys Arg Ala

145

150

155

160

**33/48**

Ser Lys Ser Ile Ser Lys Tyr Leu Ala Trp Tyr Gln Glu Lys Pro Gly

165

170

175

Lys Thr Asn Lys Leu Leu Ile Tyr Ser Gly Ser Thr Leu Gln Ser Gly

180

185

190

Ile Pro Ser Arg Phe Ser Gly Ser Gly Ser Gly Thr Asp Phe Thr Leu

195

200

205

Thr Ile Ser Ser Leu Glu Pro Glu Asp Phe Ala Met Tyr Tyr Cys Gln

210

215

220

Gln His Asn Glu Tyr Pro Tyr Thr Phe Gly Gly Thr Lys Leu Glu

225

230

235

240

Ile Lys

<210> 66

<211> 744

<212> DNA

<213> Mus sp.

<400> 66

gaggtgcagc tgctcgagca gtctggagct gagctggtaa ggccctgggac ttcaagtgaag 60

atatcctgca aggcttctgg atacgccttc actaactact ggcttaggttg ggttaaggcag 120

aggcctggac atggacttga atgggttgaa gatatttcc ctggaagtgg taatgctcac 180

tacaatgaga agttcaaggg caaagccaca ctgactgcag acaagtcctc gtacacagcc 240

tatatgcagc tcagtagcct gacatctgag gactctgctg tctattctg tgcaagattg 300

## 34/48

cggaactggg acgaggctat ggactactgg ggccaaggga ccacggtcac cgtctcctca 360  
ggtgtggtg gttctggcg cgccggctcc ggtggtggtg gttctgagct cgtgatgaca 420  
cagtctccat cctccctgag tgtgtcagca ggagagaagg tcactatgag ctgcaagtcc 480  
agtcagagtc tgtaaacag tggaaatcaa aagaactact tggcctggta ccagcagaaa 540  
ccagggcagc ctccctaaact gttgatctac gggcatcca ctaggaaatc tggggtccct 600  
gatecgcttca caggcagtgg atctggaaca gatttcactc tcaccatca gagtgtgcag 660  
gctgaagacc tggcagtttta ttactgtcag aatgattata gttatccgta cacgttcgga 720  
ggggggacca agcttgagat caaa 744

<210> 67

<211> 248

<212> PRT

<213> Mus sp.

<400> 67

Glu Val Gln Leu Leu Glu Gln Ser Gly Ala Glu Leu Val Arg Pro Gly

1

5

10

15

Thr Ser Val Lys Ile Ser Cys Lys Ala Ser Gly Tyr Ala Phe Thr Asn

20

25

30

Tyr Trp Leu Gly Trp Val Lys Gln Arg Pro Gly His Gly Leu Glu Trp

35

40

45

Val Gly Asp Ile Phe Pro Gly Ser Gly Asn Ala His Tyr Asn Glu Lys

50

55

60

Phe Lys Gly Lys Ala Thr Leu Thr Ala Asp Lys Ser Ser Tyr Thr Ala

65

70

75

80

35/48

Tyr Met Gln Leu Ser Ser Leu Thr Ser Glu Asp Ser Ala Val Tyr Phe

85

90

95

Cys Ala Arg Leu Arg Asn Trp Asp Glu Ala Met Asp Tyr Trp Gly Gln

100

105

110

Gly Thr Thr Val Thr Val Ser Ser Gly Gly Gly Ser Gly Gly Gly

115

120

125

Gly Ser Gly Gly Ser Glu Leu Val Met Thr Gln Ser Pro Ser

130

135

140

Ser Leu Ser Val Ser Ala Gly Glu Lys Val Thr Met Ser Cys Lys Ser

145

150

155

160.

Ser Gln Ser Leu Leu Asn Ser Gly Asn Gln Lys Asn Tyr Leu Ala Trp

165

170

175

Tyr Gln Gln Lys Pro Gly Gln Pro Pro Lys Leu Leu Ile Tyr Gly Ala

180

185

190

Ser Thr Arg Glu Ser Gly Val Pro Asp Arg Phe Thr Gly Ser Gly Ser

195

200

205

Gly Thr Asp Phe Thr Leu Thr Ile Ser Ser Val Gln Ala Glu Asp Leu

210

215

220

Ala Val Tyr Tyr Cys Gln Asn Asp Tyr Ser Tyr Pro Tyr Thr Phe Gly

225

230

235

240

Gly Gly Thr Lys Leu Glu Ile Lys

245

<210> 68

<211> 726

<212> DNA

<213> Mus sp.

<400> 68

gaggtgcagc tgctcgagca gtctggagct gagctggta ggcctgggc ttcagtgaag 60  
atatcctgca aggcttctgg atacgccttc aataactact ggcttaggtg ggtaaagcag 120  
aggcctggac atggacttga gtggatttga gacatttacc ctggaagtgg aaataactcac 180  
tacaatgaga gtttcagggg caaagccaca ctgactgcag acaaattcctc gagcacagcc 240  
tttatgcagt taatgtgcct gacatctgag gactctgctg tctatattctg tgcaagattg 300  
aggaactggg acgaggctat ggactactgg ggccaaggga ccacggtcac cgtctcctca 360  
ggtgtggtg gttctggcg cgccggctcc ggtgggtgt gttctgagct cgtcatgacc 420  
cagtctccat cttatcttgc tgcattctcct ggagaaacca ttactattaa ttgcaggca 480  
agtaagagca ttagcaaata tttagcctgg tatcaagaga aacctggaa aactaataag 540  
cttcttatct actctggatc cactttgcaa tctggaattc catcaagggtt cagttggcagt 600  
ggatctggta cagatttcac tctcaccatc agtagcctgg agcctgaaga ttttgcaatg 660  
tattactgtc aacagcataa tgaatacccg tacacgttcg gaggggggac caagcttgag 720  
atcaaa 726

<210> 69

<211> 242

<212> PRT

<213> Mus sp.

37/48

&lt;400&gt; 69

Glu Val Gln Leu Leu Glu Gln Ser Gly Ala Glu Leu Val Arg Pro Gly

1 5 10 15

Ala Ser Val Lys Ile Ser Cys Lys Ala Ser Gly Tyr Ala Phe Asn Asn

20 25 30

Tyr Trp Leu Gly Trp Val Lys Gln Arg Pro Gly His Gly Leu Glu Trp

35 40 45

Ile Gly Asp Ile Tyr Pro Gly Ser Gly Asn Thr His Tyr Asn Glu Arg

50 55 60

Phe Arg Gly Lys Ala Thr Leu Thr Ala Asp Lys Ser Ser Ser Thr Ala

65 70 75 80

Phe Met Gln Leu Ser Ser Leu Thr Ser Glu Asp Ser Ala Val Tyr Phe

85 90 95

Cys Ala Arg Leu Arg Asn Trp Asp Glu Ala Met Asp Tyr Trp Gly Gln

100 105 110

Gly Thr Thr Val Thr Val Ser Ser Gly Gly Gly Ser Gly Gly Gly

115 120 125

Gly Ser Gly Gly Gly Ser Glu Leu Val Met Thr Gln Ser Pro Ser

130 135 140

Tyr Leu Ala Ala Ser Pro Gly Glu Thr Ile Thr Ile Asn Cys Arg Ala

145 150 155 160

Ser Lys Ser Ile Ser Lys Tyr Leu Ala Trp Tyr Gln Glu Lys Pro Gly

165

170

175

Lys Thr Asn Lys Leu Leu Ile Tyr Ser Gly Ser Thr Leu Gln Ser Gly

180

185

190

Ile Pro Ser Arg Phe Ser Gly Ser Gly Ser Gly Thr Asp Phe Thr Leu

195

200

205

Thr Ile Ser Ser Leu Glu Pro Glu Asp Phe Ala Met Tyr Tyr Cys Gln

210

215

220

Gln His Asn Glu Tyr Pro Tyr Thr Phe Gly Gly Gly Thr Lys Leu Glu

225

230

235

240

Ile Lys

<210> 70

<211> 753

<212> DNA

<213> Mus sp.

<400> 70

gaggtgcagc tgctcgagca gtctggagct gagctggcga ggcctggggc ttcagtgaag 60

ctgtcctgca aggctctgg ctacaccttc acaaactatg gtttaagctg ggtgaagcag 120

aggcctggac aggtccttga gtggatttgg a gaggttatc ctagaatttg taatgcttac 180

39/48

tacaatgaga agttcaaggg caaggccaca ctgactgcag acaaattcctc cagcacagcg 240  
tccatggagc tccgcagcct gacctctgag gactctgcgg tctatttctg tgcaagacgg 300  
ggatcctacg atactaacta cgactggtag ttcatgtct ggggccaagg gaccacggtc 360  
accgtctcct caggtggtag tggttctggc ggccggcggct ccggtggtgg tggttctgag 420  
ctcgtatga cccagactcc actctccctg cctgtcagtc ttggagatca agcctccatc 480  
tcttcagat ctagtcagag cttgtacac agtaatggaa acacctattt acattggtag 540  
ctgcagaagc caggccagtc tccaaagctc ctgatctaca aagtttccaa ccgattttct 600  
gggtcccag acaggttcag tggcagtggta tcagggacag atttcacact caagatcagc 660  
agagtggagg ctgaggatct gggagtttat ttctgctctc aaagtacaca tgttccgtac 720  
acgttcggag gggggaccaa gcttgagatc aaa 753

&lt;210&gt; 71

&lt;211&gt; 251

&lt;212&gt; PRT

&lt;213&gt; Mus sp.

&lt;400&gt; 71

Glu Val Gln Leu Leu Glu Gln Ser Gly Ala Glu Leu Ala Arg Pro Gly

1 5 10 15

Ala Ser Val Lys Leu Ser Cys Lys Ala Ser Gly Tyr Thr Phe Thr Asn

20 25 30

Tyr Gly Leu Ser Trp Val Lys Gln Arg Pro Gly Gln Val Leu Glu Trp

35 40 45

Ile Gly Glu Val Tyr Pro Arg Ile Gly Asn Ala Tyr Tyr Asn Glu Lys

50 55 60

Phe Lys Gly Lys Ala Thr Leu Thr Ala Asp Lys Ser Ser Ser Thr Ala

**40/48**

65                    70                    75                    80

Ser Met Glu Leu Arg Ser Leu Thr Ser Glu Asp Ser Ala Val Tyr Phe

85                    90                    95

Cys Ala Arg Arg Gly Ser Tyr Asp Thr Asn Tyr Asp Trp Tyr Phe Asp

100                  105                  110

Val Trp Gly Gln Gly Thr Thr Val Thr Val Ser Ser Gly Gly Gly

115                  120                  125

Ser Gly Gly Gly Ser Gly Gly Ser Glu Leu Val Met Thr

130                  135                  140

Gln Thr Pro Leu Ser Leu Pro Val Ser Leu Gly Asp Gln Ala Ser Ile

145                  150                  155                  160

Ser Cys Arg Ser Ser Gln Ser Leu Val His Ser Asn Gly Asn Thr Tyr

165                  170                  175

Leu His Trp Tyr Leu Gln Lys Pro Gly Gln Ser Pro Lys Leu Leu Ile

180                  185                  190

Tyr Lys Val Ser Asn Arg Phe Ser Gly Val Pro Asp Arg Phe Ser Gly

195                  200                  205

Ser Gly Ser Gly Thr Asp Phe Thr Leu Lys Ile Ser Arg Val Glu Ala

210                  215                  220

**41/48**

Glu Asp Leu Gly Val Tyr Phe Cys Ser Gln Ser Thr His Val Pro Tyr  
225                    230                    235                    240

Thr Phe Gly Gly Thr Lys Leu Glu Ile Lys  
245                    250

<210> 72

<211> 717

<212> DNA

<213> Mus sp.

<400> 72

gaggtgcagc tgctcgagtc tggagggtggc ctgggtgcagc ctggaggatc cctgaaactc 60  
tcctgtgcag cctcaggatt cgattttagt agatactgga ttagttgggt ccggcaggct 120  
ccagggaaag ggctagaatg gattggagaa attaatccag atagcagttac gataaaactat 180  
acgccatctc tgaaggataa attcatcatc tccagagaca acgccaaaaa tacgctgtac 240  
ctgcaaatgg gcaaagttagt atctgaggac acagcccttt attactgtgc aagaggagcc 300  
ttcccttttg actactgggg ccaagggacc acggtcaccc ttcctcagg tggtggtgg 360  
tctggcggcg gcggctccgg tggtggtgg tctgagctcg tgctcaccca gtctccaacc 420  
accatggctg catctcccg ggagaagatc actatcacct gcagtgccag ctcaagtata 480  
agttccaaatt acttgcattt gatatcagcag aagccaggat tctcccctaa actcttgatt 540  
tataggacat ccaatctggc ttctggagtc ccagctcgct tcagtggcag tgggtctggg 600  
acctcttact ctctcacaat tggcaccatg gaggctgaag atgttgccac ttactactgc 660  
cagcagggtt gtagtataacc actcacgttc ggtgctggga ccaagcttga gatcaaa 717

<210> 73

<211> 239

<212> PRT

<213> Mus sp.

<400> 73

Glu Val Gln Leu Leu Glu Ser Gly Gly Gly Leu Val Gln Pro Gly Gly

1 5 10 15

Ser Leu Lys Leu Ser Cys Ala Ala Ser Gly Phe Asp Phe Ser Arg Tyr

20 25 30

Trp Met Ser Trp Val Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Ile

35 40 45

Gly Glu Ile Asn Pro Asp Ser Ser Thr Ile Asn Tyr Thr Pro Ser Leu

50 55 60

Lys Asp Lys Phe Ile Ile Ser Arg Asp Asn Ala Lys Asn Thr Leu Tyr

65 70 75 80

Leu Gln Met Gly Lys Val Arg Ser Glu Asp Thr Ala Leu Tyr Tyr Cys

85 90 95

Ala Arg Gly Ala Phe Leu Phe Asp Tyr Trp Gly Gln Gly Thr Thr Val

100 105 110

Thr Val Ser Ser Gly Gly Ser Gly Gly Gly Ser Gly Gly

115 120 125

Gly Gly Ser Glu Leu Val Leu Thr Gln Ser Pro Thr Thr Met Ala Ala

130 135 140

Ser Pro Gly Glu Lys Ile Thr Ile Thr Cys Ser Ala Ser Ser Ser Ile

145 150 155 160

Ser Ser Asn Tyr Leu His Trp Tyr Gln Gln Lys Pro Gly Phe Ser Pro

165 170 175

Lys Leu Leu Ile Tyr Arg Thr Ser Asn Leu Ala Ser Gly Val Pro Ala

180 185 190

Arg Phe Ser Gly Ser Gly Ser Gly Thr Ser Tyr Ser Leu Thr Ile Gly

195 200 205

Thr Met Glu Ala Glu Asp Val Ala Thr Tyr Tyr Cys Gln Gln Gly Ser

43/48

210                    215                    220  
Ser Ile Pro Leu Thr Phe Gly Ala Gly Thr Lys Leu Glu Ile Lys  
225                    230                    235

<210> 74  
<211> 744  
<212> DNA  
<213> Mus sp.

<400> 74

gagggtgcagc tgctcgagca gtctggagct gagctggtaa ggccctggac ttcagtgaag 60  
atatcctgca aggcttctgg atacgccttc actaactact ggcttaggttg ggtaaagcag 120  
aggcctggac atggacttga gtggatttga gatatttcc ctggaaagtgg taatatccac 180  
tacaatgaga agttcaaggg caaagccaca ctgactgcag acaaatcttc gaggcacagcc 240  
tatatgcagc tcagtagcct gacatttgag gactctgctg tctatttctg tgcaagactg 300  
aggaactggg acgagccat ggactactgg ggccaaggga ccacggtcac cgtctccctca 360  
ggtgtgtgtg gttctggcgg cggcggctcc ggttgtgtg gttctgagct cgtgatgaca 420  
cagtctccat cctccctgac tgtgacagaca ggagagaagg tcactatgag ctgcaagtcc 480  
agtcaagatc tgttaaacag tggaaatcaa aagaactact tgacctggta ccagcagaaa 540  
ccagggcagc ctccctaaact gttgatctac tggcatcca ctaggaaatc tgggtccct 600  
gatcgcttca caggcagtgg atctggAACa gatttcaactc tcaccatcag cagtgtgcag 660  
gctgaagacc tggcagttta ttactgtcag aatgattata gttatccgct cacgttcggt 720  
gctgggacca aqcttqagat caaa 744

<210> 75  
<211> 248  
<212> PRT  
<213> Mus sp.

<400> 75

**44/48**

Glu Val Gln Leu Leu Glu Gln Ser Gly Ala Glu Leu Val Arg Pro Gly

1

5

10

15

Thr Ser Val Lys Ile Ser Cys Lys Ala Ser Gly Tyr Ala Phe Thr Asn

20

25

30

Tyr Trp Leu Gly Trp Val Lys Gln Arg Pro Gly His Gly Leu Glu Trp

35

40

45

Ile Gly Asp Ile Phe Pro Gly Ser Gly Asn Ile His Tyr Asn Glu Lys

50

55

60

Phe Lys Gly Lys Ala Thr Leu Thr Ala Asp Lys Ser Ser Ser Thr Ala

65

70

75

80

Tyr Met Gln Leu Ser Ser Leu Thr Phe Glu Asp Ser Ala Val Tyr Phe

85

90

95

Cys Ala Arg Leu Arg Asn Trp Asp Glu Pro Met Asp Tyr Trp Gly Gln

100

105

110

Gly Thr Thr Val Thr Val Ser Ser Gly Gly Gly Ser Gly Gly Gly

115

120

125

Gly Ser Gly Gly Gly Ser Glu Leu Val Met Thr Gln Ser Pro Ser

130

135

140

Ser Leu Thr Val Thr Ala Gly Glu Lys Val Thr Met Ser Cys Lys Ser

145

150

155

160

**45/48**

Ser Gln Ser Leu Leu Asn Ser Gly Asn Gln Lys Asn Tyr Leu Thr Trp

165

170

175

Tyr Gln Gln Lys Pro Gly Gln Pro Pro Lys Leu Leu Ile Tyr Trp Ala

180

185

190

Ser Thr Arg Glu Ser Gly Val Pro Asp Arg Phe Thr Gly Ser Gly

195

200

205

Gly Thr Asp Phe Thr Leu Thr Ile Ser Ser Val Gln Ala Glu Asp Leu

210

215

220

Ala Val Tyr Tyr Cys Gln Asn Asp Tyr Ser Tyr Pro Leu Thr Phe Gly

225

230

235

240

Ala Gly Thr Lys Leu Glu Ile Lys

245

&lt;210&gt; 76

&lt;211&gt; 744

&lt;212&gt; DNA

&lt;213&gt; Mus sp.

&lt;400&gt; 76

gaggtgcagc tgctcgagca gtctggagct gagctggtaa ggcctggac ttcagtgaag 60

atatcctgca aggcttctgg atacgccttc actaactact ggcttaggttg ggttaagcag 120

aggcctggac atggacttga atgggttgg aatatttcc ctggaagtgg taatgctcac 180

tacaatgaga agttcaaggg caaagccaca ctgactgcag acaagtcctc gtacacagcc 240

tatatgcagc tcagtagcct gacatctgag gactctgctg tctatttctg tgcaagattg 300  
cggaactggg acgaggctat ggactactgg ggccaaggga ccacggtcac cgtctcctca 360  
ggtgtggtg gttctggcgg cggcggctcc ggtggtggtg gttctgagct cgtgatgaca 420  
cagtctccat cctccctggc tatgtcagta ggacagaagg tcactatgag ctgcaagtcc 480  
agtca gagcc ttttaaatag tagcaatcaa aagaactatt tggcctggta ccagcagaaa 540  
caagggcagc ctccctaaact gcttatctat ggggcatcca ttagagaatc ttgggtccct 600  
gatcgattca caggaagtgg atctgggaca gacttcactc tcaccatcag cagtgtgaag 660  
gctgaagacc tggcagttt aatactgtcag caatattata gctatccgta cacgttcgga 720  
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<211> 248

<212> PRT

<213> Mus sp.

<400> 77

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15

Thr Ser Val Lys Ile Ser Cys Lys Ala Ser Gly Tyr Ala Phe Thr Asn

20

25

30

Tyr Trp Leu Gly Trp Val Lys Gln Arg Pro Gly His Gly Leu Glu Trp

35

40

45

Val Gly Asp Ile Phe Pro Gly Ser Gly Asp Ala His Tyr Asp Glu Lys

50

55

60

Phe Lys Gly Lys Ala Thr Leu Thr Ala Asp Lys Ser Ser Tyr Thr Ala

65

70

76

Tyr Met Gln Leu Ser Ser Leu Thr Ser Glu Asp Ser Ala Val Tyr Phe

85 90 95

Cys Ala Arg Leu Arg Asn Trp Asp Glu Ala Met Asp Tyr Trp Gly Gln

100 105 110

Gly Thr Thr Val Thr Val Ser Ser Gly Gly Gly Ser Gly Gly Gly

115 120 125

Gly Ser Gly Gly Gly Ser Glu Leu Val Met Thr Gln Ser Pro Ser

130 135 140

Ser Leu Ala Met Ser Val Gly Gln Lys Val Thr Met Ser Cys Lys Ser

145 150 155 160

Ser Gln Ser Leu Leu Asn Ser Ser Asn Gln Lys Asn Tyr Leu Ala Trp

165 170 175

Tyr Gln Gln Lys Gln Gly Gln Pro Pro Lys Leu Leu Ile Tyr Gly Ala

180 185 190

Ser Ile Arg Glu Ser Trp Val Pro Asp Arg Phe Thr Gly Ser Gly Ser

195 200 205

Gly Thr Asp Phe Thr Leu Thr Ile Ser Ser Val Lys Ala Glu Asp Leu

210 215 220

Ala Val Tyr Tyr Cys Gln Gln Tyr Tyr Ser Tyr Pro Tyr Thr Phe Gly

**48/48**

225

230

235

240

Gly Gly Thr Lys Leu Glu Ile Lys

245